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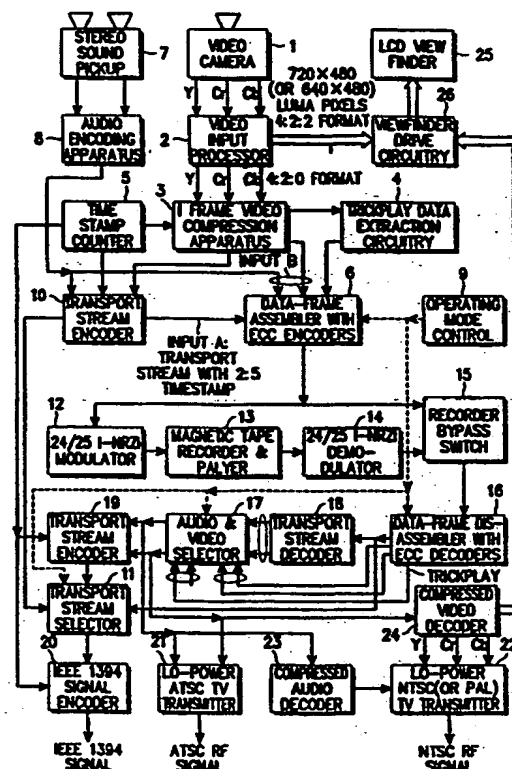
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(54) Title: VIDEO TRANSMISSION APPARATUS EMPLOYING INTRA-FRAME-ONLY VIDEO COMPRESSION THAT IS MPEG-2 COMPATIBLE

(57) Abstract

Intraframe-only video compression encoding of every successive video frame is done the way intraframe video compression encoding is done on I anchor frames in MPEG-2, and each frame is identified as being intraframe video compression encoded similarly to the way it is done on I anchor frames in MPEG-2. The encoder for doing this is simpler than that for coding P frames and B frames as well as I frames, since there is no need for motion estimation circuitry. Using such an encoder in a digital camcorder reduces power drain on the battery and permits the weight and size of the camcorder to be reduced. Intraframe-only video compression facilitates editing video. In many systems in which video editing is done an MPEG-2 decoder is already available, so there is no additional cost for a decoder to decode the transport stream of I frames without intervening P or B frames. If an MPEG-2 decoder is not already available in a system, providing such a decoder is reasonable in cost, since the amount of hardware in an MPEG-2 decoder is considerably less than that in an MPEG-2 encoder.



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VIDEO TRANSMISSION APPARATUS EMPLOYING INTRA-FRAME-ONLY
VIDEO COMPRESSION THAT IS MPEG-2 COMPATIBLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 The invention relates to video compression techniques and, more particularly, to video compression techniques that are adapted for use with digital camcorders or with other digital tape recording and playback apparatus when video editing capabilities are
10 desired.

2. Description of the Related Art

Digital video cassette (DVC) electromagnetic tape recording is currently done using standards developed in a High-Definition Digital Video-Cassette-Recorder
15 Conference. Five standards were established in that conference, including a standard for standard density (SD) recording in which one frame of NTSC video is recorded in 1350 syncblocks. These 1350 syncblocks, 90
20 syncblocks of accompanying audio and 44 syncblocks of overhead are distributed amongst ten successive helically recorded tracks on the electromagnetic recording tape. Syncblocks are uniform in bit length, and five syncblocks comprise a segment of five
25 macroblocks of DCT. Each block of DCT is based on an 8-pixel-by-8-pixel block of 4:2:0 image data. That is, luminance (Y) is sampled twice as densely in the horizontal direction and in the vertical direction as the red-minus-luminance color difference signal (Cr) and as the blue-minus-luminance color difference signal
30 (Cb). Each macroblock contains four blocks of discrete cosine transform (DCT) descriptive of Y and two blocks descriptive of Cr and Cb, which blocks are of variable bit length. While there are 385 bytes per segment in

- 2 -

the SD standard, often as few as a hundred or less are required for transmitting DCT-capable of generating images of requisite resolution. One of the objectives of the inventors was to more efficiently utilize the bytes available in each successive group of ten tracks, so that the number of null bytes is reduced and so that image resolution is improved by using those previously unused bytes.

The HD Digital VCR Conference established a high-density (HD) baseband standard in which each frame of a high-resolution television picture, together with accompanying audio and overhead, occupies twenty consecutive recording tracks. The conference defined further standards for recording direct video broadcasting (DVB), advanced television (ATV), PAL+ for Europe and EDTV-II for Japan. For the most part, the recording scheme for DVB simply involves the payload being formed from segments of the transport stream for this transmission medium. A similar observation can be made concerning the recording scheme for DVB. However, there are rules for the insertion of data to support trickplay reproduction from the recording, in addition to normal reproduction.

The high-resolution TV picture contemplated for HD baseband recording is of MUSE type with 1125 scan lines and 1200 luminance pixels per scan line. Those skilled in the art recognize that the HD baseband standard does not conform to any of the formats supported by the high-definition broadcast television standard established by the Advanced Television Standards Committee. The ATSC standard supports 480 scan lines with 640 luminance pixels per interlaced scan line, 480 scan lines with 720 luminance pixels per interlaced or progressive scan line, 720 scan lines with 1280

- 3 -

luminance pixels per progressive scan line, and 1080 scan lines with 1920 luminance pixels per interlaced scan line. A known practice is to record two data segments of ATSC digital television signal, each preceded by a time stamp, in five syncblocks of DTV signal.

The audio signals used as source signals in TV broadcasting are sampled at a frequency of 48 kHz, locked to the 27 MHz system clock, and are encoded according to the digital audio compression (AC-3) standard specified in the body of ATSC document A/52. The resulting compressed audio information is parsed into packets identified in the packet headers as being audio packets.

The video signals used as source signals in TV broadcasting are encoded according to the MPEG-2 video compression standard. The resulting compressed video information is parsed into packets identified in the packet headers as being video packets. Transmission is by groups of pictures, each group of pictures (GOP) containing coding for an initial anchor frame referred to as an "I frame", subjected solely to intraframe video compression, followed by coding for a succession of other frames subjected to interframe compression coding. These other frames comprise so-called "P frames" and so-called "B frames". Coding for each P frame is based on differences of that video frame in actuality from that frame as predicted by extrapolation from a most recent previous one of the I and P frames, in accordance with motion vectors derived by block comparison between the more recent of these previous I and P frames. Coding for each B frame is based on differences of that video frame in actuality from that frame as predicted by bidirectional

interpolation from a preceding one and a succeeding one of the I and P frames.

MPEG-2 compressed video is suited to an application, such as television broadcasting, where
5 there is not much concern with regard to the difficulty of editing video information in this transport stream format. In applications where ease of editing video is of concern, preferably video compression is done relying not at all on interframe compression
10 techniques, but just on intraframe video compression techniques. Ease of editing video is desirable for editing of video recordings to delete undesired frames, to introduce frame repetition for achieving slow-motion or
15 stop-motion effects, and to insert reverse motion sequences. By way of further examples, ease of editing video is also desirable for extracting still pictures from camcorder recordings, for extracting selected video for transmission over the internet and for
20 editing commercials out of video recorded from broadcast television.

In systems for processing video in which ease of editing video is of concern, the inventors advocate intraframe video compression encoding every successive
25 video frame in accordance with the way intraframe video compression encoding is done on I anchor frames in MPEG-2 and then identifying each frame as being intraframe video compression encoded similarly to the way it is done for anchor frames in MPEG-2. A
30 conventional MPEG-2 encoder can be modified to carry out this video compression algorithm. Alternatively, the encoder for encoding just anchor or I frames can be considerably simplified from the encoder required for coding P frames and B frames as well as I frames, since

there is no need for the motion estimation circuitry that forms a substantial part of a complete MPEG-2 encoder. The motion estimation circuitry requires memory with storage capability for plural frames of video information. The inventors prefer such a simplified encoder be used in a digital camcorder for reducing power drain on the camcorder battery and for shaving the weight and size of the camcorder.

In many systems for processing video in which ease of editing video is of concern, an MPEG-2 decoder is already available for use in decoding continuous intraframe video compression encoding descriptive of consecutive video frames, so there is no additional cost for a decoder to decode the transport stream of I frames without intervening P or B frames. If an MPEG-2 decoder is not already available in a system, providing such a decoder is reasonable in cost, since the amount of hardware in an MPEG-2 decoder is considerably less than that in an MPEG-2 encoder. Alternatively, a modified MPEG-2 decoder only for I frames can be used.

SUMMARY OF THE INVENTION

The invention in one of its aspects is embodied in a digital video recorder with a video compression encoder for generating consecutive I frames according to the MPEG-2 standard, but in a departure from the MPEG-2 standard without intervening P or B frames. The invention in a more particular one of its aspects is embodied in a digital camcorder with a video compression encoder for generating consecutive I frames according to the MPEG-2 standard, but in a departure from the MPEG-2 standard without intervening P or B frames. The invention in a still more particular one of its aspects is embodied in a digital video recorder or digital camcorder with a video compression encoder

for generating a continuous succession of I frames according to the MPEG-2 standard, which video compression encoder is simplified so as not to have capability for encoding P frames or B frames.

5 The invention in another one of its aspects is embodied in a digital video recorder or digital camcorder with a video compression encoder for generating a continuous succession of I frames that can be recorded either as an elementary video stream
10 without the use of 2:5 conversion or as a transport stream using 2:5 conversion, which transport stream is formed in accordance with a modification of the MPEG-2 standard which includes I frames but not intervening P or B frames

15 BRIEF DESCRIPTION OF THE DRAWING

FIGURES 1, 2, 3 and 4 are each a schematic diagram of a respective camcorder embodying the invention in certain of its aspects.

FIGURES 5, 6, 7, 8, 9 and 10 are each a schematic
20 diagram of a respective digital tape recorder and player embodying the invention in certain of its aspects, connected in a system embodying the invention in further of its aspects.

FIGURE 11 is a detailed schematic diagram of
25 compressed video signal generation circuitry that can be used in the apparatus of FIGURE 1 or 3, 5, 7 or 9.

FIGURE 12 is a detailed schematic diagram of compressed video signal generation circuitry that can be used in the apparatus of FIGURE 2, 4, 6, 8 or 10.

30 FIGURE 13 is a diagram indicating how in a modification of the digital tape recorder and player of FIGURE 5, 6, 7, 8, 9 or 10 an MPEG-2 decoder is used in replacing the video compression apparatus for generating consecutive I frames only.

- 7 -

FIGURE 14 is a schematic diagram of snapshot apparatus as can be used with the camcorder of FIGURE 1 or 2, or with the digital tape recorder and player of FIGURE 5 or 6.

5 FIGURE 15 is a schematic diagram of snapshot apparatus as can be used with the camcorder of FIGURE 3 or 4, or with the digital tape recorder and player of FIGURE 7, 8, 9 or 10.

FIGURE 16 is a schematic diagram of a system including a computer with video and audio editing software, which system is operated for editing video in accordance with the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGURE 1 shows a camcorder in which video
15 compression is done in accordance with the invention. A video camera 1 generates frames of video information in 4:3 aspect ratio including luminance (Y) information having 480 active scan lines in each frame and 720 (or, alternatively, 640) pixels in each scan line. In a
20 camcorder for home use the video camera 1 generally employs a single solid-state imager with a color pattern filter; in a camcorder for broadcast use the video camera 1 generally employs beam splitter optics with respective solid-state imager for each of three
25 additive primary colors. Either type of video camera 1 is presumed to include color matrixing circuitry such that the video camera 1 supplies luminance (Y) information, red-minus-luminance (Cr) chrominance information, and
30 blue-minus-luminance (Cb) chrominance information as the components of video information in 4:2:2 format.

A video input processor 2 converts the Y, Cr, and Cb signals to 4:2:0 sampling format by performing a 2:1 decimation of each of the Cr and Cb signals in both

the vertical and the horizontal directions after separable lowpass anti-aliasing filtering in both directions. The video information from the video camera 1 has two line interlaced fields in each frame of one-thirtieth second duration, or instead is progressively scanned with frames each of one-sixtieth second duration. Designs for respective lowpass anti-aliasing filtering appropriate for each alternative are known to persons skilled in the art.

10 If there are two line interlaced fields in each frame, a 7-tap vertical lowpass anti-aliasing filter is used in odd fields; and a 4-tap vertical lowpass anti-aliasing filter is used in even fields. Then the earlier and later fields of each frame are interlaced line by line into a complete frame for compression encoding. This procedure generates a succession of frames each of one-thirtieth second duration.

 If the video camera 1 supplies progressive scan video information with frames each of one-sixtieth second duration, after the video input processor 2 converts the Y, Cr, and Cb signals to 4:2:0 sampling format, the number of frames can be decimated 2:1 by using a pseudo field interlace method to generate pseudo-field-interlace frames occurring at halved frame rate. Suppose the frames of video information are numbered modulo-2 that in order of their occurrence, and the lines in each frame are consecutively numbered in order of their occurrence. The amplitudes of Y, Cr, and Cb pixels in odd scan lines of each odd frame are combined with their counterparts in the immediately preceding even frame to generate odd-line fields of the pseudo-field-interlace frames occurring at halved frame rate. The amplitudes of Y, Cr, and Cb pixels in even

scan lines of each odd frame are combined with their counterparts in the immediately succeeding even frame to generate even-line fields of the pseudo-field-interlace frames occurring at halved frame rate.

5 Video compression apparatus 3 receives the Y, Cr, and Cb signals in 4:2:0 sampling format for video compression encoding. Video compression apparatus 3 also receives the output count of a time stamp counter 5, which counts system clock cycles in each group of
10 sixteen video frames. This output count accompanies compressed video signal components in order to keep track of the order in which they were generated. Video compression encoding is carried out on an intraframe basis on every one of the frames. This is done in
15 accordance with the same intraframe compression encoding protocol used on only the first, anchor frame of each group of pictures in MPEG-2 video compression encoding. This intraframe compression encoding protocol proceeds by considering each frame of the Y, Cr, and Cb signal samples to be composed of a close-
20 packed array of 8-pixel-by-8-pixel blocks arranged in rows and in columns. The discrete cosine transform (DCT) of each of these

8-pixel-by-8-pixel blocks is calculated in a prescribed
25 order. The DCT coefficients of each 8-pixel-by-8-pixel block of video signal samples are quantized and supplied in a prescribed order as bit-serial binary numbers to form a string of bits descriptive of a respective DCT block. The succession of DCT blocks are
30 then entropy encoded, which includes run-length coding followed by variable-length encoding based upon a table of presumed statistics. The MPEG-2 standard for video compression includes recommended tables for entropy

- 10 -

encoding. Quantization of the DCT results is adjusted in order that the intraframe coding result for each frame fits within a 103,950 byte limit (77 bytes of data per sync block times 1350 sync blocks of video information per NTSC frame).

The video compression apparatus 3 supplies compressed video information for each consecutive frame generated according to the MPEG-2 intraframe-coding algorithms for I frames. The sequence headers, GOP headers, picture headers, slice headers and macroblock headers are inserted into this compressed video information by the video compression apparatus 3. The picture header includes an I-frame coding flag, which will condition any MPEG-2 decoder used during playback from the videocassette recording to decode the compressed video information on an intraframe basis. This is so whether the compressed video information is recorded directly or is recorded after being encoded into an MPEG-2 transport stream.

The FIGURE 1 camcorder is designed to be compatible with a digital videocassette recorder and player in regard to trickplay. Trickplay extraction circuitry 4 extracts trickplay information comprising the zero-frequency and other low-frequency DCT coefficients of the succession of DCT blocks of every anchor frame as computed in the video compression apparatus 3. When in accordance with the invention every frame is encoded as an anchor I frame, the trickplay information changes more frequently than in conventional MPEG-2 encoding, but this is acceptable. In a variant of the just described procedure, every frame is encoded as an I frame, but only every sixteenth frame is treated as an anchor frame. In

- 11 -

these alternate embodiments of the invention, every sixteenth frame is stored for a sixteen-frame period and used to support generation of trickplay information, more like what is done in conventional MPEG-2 encoding. However, embodiments of the invention not using this variant are currently preferred, since avoiding frame storage for every sixteenth frame reduces the cost and complexity of the video compression apparatus 3 appreciably. The trickplay extraction circuitry 4 parses the truncated DCT blocks so extracted into syncblocks supplied to a data-frame assembler 6 for insertion amongst other syncblocks containing time stamps and further containing video or audio packets. The insertion is done in accordance with a conventional prescribed pattern that forms bands of trickplay information in alternate recording tracks on the magnetic tape. The data-frame assembler 6 is otherwise the same as those used in a standard-definition digital-video-cassette recorder (SD DVCR).

Stereo sound pickup apparatus 7 is presumed to be associated with the video camera 1 in the FIGURE 1 camcorder and to supply a left-channel (L) signal and a right-channel (R) signal. The L and R signals are supplied to audio encoding apparatus 8 for compression encoding that generates compressed audio information. Compression encoding can be done in any of a number of ways such as according to MPEG standard, according to the AC-3 standard when recording digital television as broadcast in the United States, or according to a pulse code modulation (PCM) scheme.

Responsive to a control setting by a user of the FIGURE 1 camcorder, an operating mode control 9

- 12 -

conditions the camcorder to operate in accordance with a first data-frame-assembly mode. In this mode the compressed video information from the video compression apparatus 3 and the compressed audio information from the audio encoding apparatus 8 are utilized directly by a data-frame assembler 6. The assembler 6 includes forward error-correction-code encoders for video and for audio. The compressed video information is temporarily stored in row and column array within a video portion of memory in the assembler 6. The compressed audio information is temporarily stored in row and column array within an audio portion of memory in the assembler 6. Per custom in SD DVCRs, the forward ECC encoder for video is a two-dimensional Reed-Solomon encoder using (149,138) outer coding circuitry and (85, 77) inner coding circuitry. The video portion of the memory in the assembler 6 is operated as an interleaver for this forward ECC encoder. Per custom in SD DVCRs, the forward ECC encoder for audio is a two-dimensional Reed-Solomon encoder using (14,9) outer coding circuitry and (85, 77) inner coding circuitry, with the audio portion of the memory in the assembler 6 being operated as an interleaver for this forward ECC encoder. The data-frame assembler 6 includes circuitry for prefacing each 85-byte row of forward error-correction-coded information with a 5-byte header when read as a syncblock from the memory in the assembler 6. This 5-byte header comprises a 2-byte synchronization code followed by a 3-byte identification (ID) code.

The operating mode control 9 can alternatively have a user control setting that conditions the FIGURE

- 13 -

1 camcorder for operation in accordance with a second data-frame-assembly mode. In this second data-frame-assembly mode a transport stream supplied from a transport stream encoder 10 is utilized as input signal
5 by the data-frame assembler 6, rather than the compressed video information supplied directly from the video compression apparatus 3 and the compressed audio information from the audio encoding apparatus 8. The transport stream encoder 10 parses the compressed video
10 information into pairs of consecutive MPEG-2 video packets preceded by packet headers, each beginning with a time stamp. The transport stream encoder 10 parses the compressed audio information into consecutive audio packets preceded by packet headers each beginning with
15 a time stamp. Each audio packet follows the packet header with auxiliary audio information containing codes indicative of the type of audio encoding that was used to generate the audio packets. This auxiliary audio information is forwarded to the transport stream
20 encoder 10 from the audio encoding apparatus 8. The transport stream encoder 10 assembles the video and audio packets into a first transport stream supplied to a transport stream selector 11. The transport stream encoder 10 also assembles a second transport stream
25 differing from the first transport stream in that extra time stamps as extracted from the time stamp counter 5 are inserted. This is done to implement 2:5 conversion, in which each consecutive pair of the 188-byte packets in this second transport stream are
30 written into five rows of the memory in the data-frame assembler 6, for subsequent reading as five sync blocks from the assembler 6. A set of MPEG packs that specify the specific video and audio compression formats used in generating the transport stream are loaded from the

- 14 -

transport stream encoder 10 into the data-frame assembler for insertion into the 19th, 20th and 156th syncblocks of each data frame.

The further details of the data-frame assembler 5 6 will be familiar to one skilled in the art, conforming to "Specifications of Consumer-Use Digital VCRs using 6.3 mm magnetic tape" issuing from the December 1994 HD Digital VCR Conference. The sync blocks supplied from the data-frame assembler 6 are 10 applied to a 24/25 modulator 12 as a modulating signal that governs the generation of interleaved-NRZI modulation. This I-NRZI modulation is supplied to the recording amplifier of a magnetic tape recorder (and player) 13 that is a component of the FIGURE 1 15 camcorder and is of helical recording type. The I-NRZI modulation results are without substantial direct component, so the amplified modulation results can be transformer coupled without loss of information to heads of the tape recorder 13 during times of 20 recording. This transformer coupling is done by a rotary transformer between the head drum and the main body of the tape recorder 13, which main body contains the mechanism for transporting magnetic tape recording medium past the head drum.

25 During times of playback from the magnetic tape recording medium, electric signals induced in the heads of the magnetic tape recorder and player 13 by magnetic changes in the moving medium are coupled through the rotary transformer to a playback amplifier in the 30 recorder and player 13. This playback amplifier supplies 24/25 I-NRZI modulation to a demodulator 14 for 24/25 I-NRZI modulation, which demodulator 14 reproduces the error-correction-coded syncblocks

- 15 -

supplied from the data-frame assembler 6 for recording. A recorder bypass switch 15 is set in response to the desire of a user to select either the error-correction-coded syncblocks supplied from the data-frame assembler 6 or the error-correction-coded syncblocks reproduced by the 24/25 I-NRZI demodulator 14 to be supplied to a data-frame disassembler 16.

The data-frame disassembler 16 corrects errors in the signal supplied thereto and accordingly includes decoders for the Reed-Solomon forward error-correction-codes. The data-frame disassembler 16 includes temporary-storage memory for video, which memory is operated as an interleaver for the video ECC decoder. The data-frame disassembler 16 also includes temporary-storage memory for audio, which memory is operated as an interleaver for the audio ECC decoder.

When the user control setting of the operating mode control 9 selects normal play in accordance with the first data-frame-assembly mode, an audio/video selector 17 selects as its output signal compressed video information and compressed audio information read from respective temporary-storage memory in the data-frame disassembler 16. The compressed video information and compressed audio information are read to the audio/video selector 17 after error correction of the information by the ECC decoders in the data-frame disassembler 16 has been completed. In this mode the compression-encoded-video decoder 24 decodes compressed video information from the audio/video selector 17 on an I-frame-only basis. If the compression-encoded-video decoder 24 has the capability of decoding B or P frames as well as I frames, the decoder 24 is conditioned to decode on an

- 16 -

I-frame-only basis responsive to the picture headers in the compressed video signal. If desired, the design can be such that the decoder 24 is conditioned to decode on an

- 5 I-frame-only basis responsive to the user control setting of the operating mode control 9.

When the user control setting of the operating mode control 9 selects

- normal-play in accordance with the second data-frame-assembly mode, the audio/video selector 17 selects as
10 its output signal compressed video information and compressed audio information supplied by a transport stream decoder 18. The compressed video information and compressed audio information are decoded from video
15 packets and audio packets read to the decoder 18 from respective

- temporary-storage memory in the data-frame disassembler 16. The video packets and audio packets are read to the transport stream decoder 18 after error correction
20 of the packets by the ECC decoders in the data-frame disassembler 16 has been completed. If the compression-encoded-video decoder 24 has the capability of decoding B or P frames as well as I frames, the decoder 24 is conditioned to decode on an I-frame-only
25 basis responsive to the picture headers in the compressed video signal indicating that this was the mode in which the DVCR tape cassette being played back was recorded.

- When the user control setting of the operating
30 mode control 9 selects trickplay, the output signal that the audio/video selector 17 supplies comprises null compressed audio information supplied as wired

- 17 -

input and compressed video information recorded as trickplay signal, then read from temporary-storage memory in the data-frame disassembler 16 during playback. The audio recovered by the

5 compression-encoded-audio decoder 23 is muted. If the compression-encoded-video decoder 24 has the capability of decoding B or P frames as well as I frames, the decoder 24 is conditioned to decode on an I-frame-only basis responsive to the user control setting of the
10 operating mode control 9.

The compressed video information and compressed audio information the audio/video selector 17 selects as its output signal is supplied to a transport stream encoder 19. The transport stream encoder 19 supplies
15 the transport stream selector 11 with a transport stream that is available when normal play in accordance with the first data-frame-assembly mode is the operating mode selected for the FIGURE 1 camcorder by the operating mode control 9. The transport stream
20 selector 11 responds to control setting by the user of the FIGURE 1 camcorder either to reproduce in its output signal the transport stream before recording, as supplied thereto by the transport stream encoder 10, or another transport stream after playback from the tape
25 recorder 13. The transport stream selector 11 automatically selects the output signal from the transport stream encoder 19 as this other transport stream responsive to the operating mode control 9 selecting playback in accordance with the first data-
30 frame-assembly mode. Responsive to the operating mode control 9 selecting playback in accordance with the second data-frame-assembly mode, the transport stream selector 11 automatically selects the output signal

- 18 -

from the data-frame disassembler 16 to the transport stream decoder 18 as the other transport stream after playback that the selector 11 can reproduce as its output signal.

5 In a variation from what is shown in FIGURE 1 that does not alter ultimate camcorder performance very much, the other transport stream after playback from the tape recorder 13 can always be the output signal from the transport stream encoder 19.

10 The transport stream reproduced in the output signal of the transport stream selector 11 is supplied to an IEEE 1394 signal encoder 20. The IEEE 1394 signal encoder 20 prefaces each 188-byte packet in the transport stream with a 4-byte time stamp, apportsions
15 each 192-byte time-stamped packet among shorter data blocks

(e. g., each of 96-byte length), and precedes each data block with a header for accessing the transmission line and a CIP header. The CIP header contains information
20 as to the apportionment of the 192-byte time-stamped packet and as to when data of similar characteristics is next to appear in the datastream.

FIGURE 1 shows the compressed video information and compressed audio information the audio/video
25 selector 17 selects as its output signal being applied to a low-power ATSC television transmitter 21 adapted for transmitting a radio-frequency signal to a digital television receiver. This is an optional feature for a camcorder constructed in accordance with the invention.
30 A representative low-power ATSC television transmitter 21 is described by T. P. Horowitz in U. S. patent No. 5,764,701 issued 9 June 1998 and entitled "VSB

- 19 -

MODULATOR". The compressed video information and compressed audio information played back from a magnetic tape recording is apt to exhibit some time-base instability owing to irregularities in tape motion. Such time-base instability is preferably corrected by using a time-base stabilizer for reclocking the information from a stable clock source before the information is used in the transmitter 21 to modulate a radio-frequency carrier. This is desirable so that the equalizer employed in an ATSC television receiver receiving the modulated RF carrier will operate properly. Generally, it is simpler to side-step time-base instability problems by supplying the IEEE 1394 Standard signal directly to the packet sorter in the ATSC television receiver, rather than attempting to link the camcorder to the receiver via RF input.

FIGURE 1 shows another optional feature for a camcorder constructed in accordance with the invention, a low-power NTSC television transmitter 22 adapted for transmitting a radio-frequency signal to an analog television receiver. The compressed audio information selected by the audio/video selector 17 is supplied to a compression-encoded-audio decoder 23. The compressed video information selected by the audio/video selector 17 is supplied to a compression-encoded-video decoder 24. The decoder 24 can be a conventional MPEG-2 video decoder, but is considerably simplified by being modified for decoding only I frames. The decoders 23 and 24 supply de-compressed audio information and de-compressed video information, respectively, to the transmitter 16.

The FIGURE 1 camcorder has a liquid-crystal-

- 20 -

display (LCD) viewfinder 25. During recording or previewing, viewfinder drive circuitry 26 supplies drive signals to the LCD viewfinder 25 in response to Y, Cr, and Cb signals in 4:2:0 sampling format supplied by the video input processor 2. During playback, viewfinder drive circuitry 26 supplies drive signals to the LCD view finder 25 in response to Y, Cr, and Cb signals in 4:2:0 sampling format supplied by the compression-encoded-video decoder 24. The drive signals applied to the LCD view finder 25 are typically R (red), G (green) and B (blue) drive signals.

FIGURE 2 shows a camcorder that differs from the FIGURE 1 camcorder in the way that trickplay is implemented. In the FIGURE 2 camcorder the DCT blocks are recorded in the tracks on the electromagnetic tape so that the zero-frequency and other low-frequency DCT coefficients of the succession of DCT blocks of each frame occupy leading portions of syncblocks. During trickplay these zero-frequency and other low-frequency DCT coefficients are recovered for generating a low-resolution display, and the higher-frequency DCT coefficients are discarded. Eliminating the trickplay bands conventionally used in digital video cassette recording increases the average payload data rate from 19.3 million bits per second to 23 million bits per second.

The trickplay extraction circuitry 4 is omitted in the FIGURE 2 camcorder, and the video compression apparatus 3 is replaced by video compression apparatus 103 which needs not include provisions to facilitate connection to the trickplay extraction circuitry 4. That is, conventional trickplay information is not recorded in the FIGURE 2 camcorder. The transport

- 21 -

stream decoder 10 is replaced by a transport stream decoder 110 modified to interface with the video compression apparatus 103, which interface will be described in more detail further when referring to

5 FIGURE 6 of the drawing. In the FIGURE 2 camcorder the data-frame assembler 6 is replaced by a data-frame assembler 106, which omits syncblocks descriptive of trickplay bands from its assembly procedures and increases the number of syncblocks containing normal-

10 play video packet information in each frame. The data-frame assembler 106 shuffles the order of the DCT coefficients of the succession of DCT blocks of each frame so the zero-frequency and other low-frequency DCT coefficients occupy leading portions of syncblocks.

15 The data-frame disassembler 16 is replaced by a data-frame disassembler 116 that takes into account the recorded signal omitting syncblocks descriptive of trickplay bands and replacing the omitted syncblocks with syncblocks containing further video packet

20 information.

The camcorders of FIGURES 1 and 2 employ CCIR 301 Standard video signals having sixty frames per second and 525 scan lines per frame in accordance with practice in the United States of America.

25 Modifications of these camcorders are readily made so they can employ CCIR 301 Standard video signals having fifty frames per second and 625 scan lines per frame, in accordance with practice in other countries. Such modifications embody the invention in certain of its

30 aspects.

FIGURE 3 shows a modification of the FIGURE 1 camcorder that uses a video camera 201 for generating progressively scanned frames of video information in

- 22 -

16:9 aspect ratio including luminance (Y) information having 720 active scan lines in each frame and 1280 pixels in each scan line. In a camcorder for home use the video camera 201 is apt to employ a single solid-state imager with a color pattern filter; in a
5 camcorder for broadcast use the video camera 201 is apt to employ beam splitter optics with respective solid-state imager for each of three additive primary colors. Either type of video camera 201 is presumed to include
10 color matrixing circuitry such that the video camera 201 supplies luminance (Y) information,

red-minus-luminance (Cr) chrominance information, and blue-minus-luminance (Cb) chrominance information as the components of video information in 4:2:2 format. A
15 video input processor 202 converts the Y, Cr, and Cb signals to 4:2:0 sampling format by performing a 2:1 decimation of each of the Cr and Cb signals in both the vertical and the horizontal directions after separable lowpass anti-aliasing filtering in both directions.

20 Video compression apparatus 203 receives the Y, Cr, and Cb signals in 4:2:0 sampling format for video compression encoding, which is carried out on an intraframe basis on every one of the frames in accordance with the same intraframe compression
25 encoding protocol that is used on only the first, anchor frame of each group of pictures in MPEG-2 video compression encoding. Trickplay extraction circuitry 204 extracts trickplay information for application to the to the data-frame assembler 6. This trickplay
30 information comprises the zero-frequency and other low-frequency DCT coefficients of the succession of DCT blocks of every frame (or, alternatively, of only periodically occurring frames selected as anchor frames

in less preferred embodiments of the invention), as computed in the video compression apparatus 203.

The amount of compressed video data is increased in the FIGURE 3 camcorder as compared to the FIGURE 1 camcorder, owing to the increased number of pixels per frame. So the compressed high-definition video information in each frame is permitted to occupy twenty recording tracks on the magnetic video tape in the FIGURE 3 camcorder, rather than just the ten tracks allotted to each frame of standard definition video information in the FIGURE 1 camcorder.

The low-power NTSC television transmitter 22 is dispensed with, owing to the video camera 201 for generating progressively scanned frames of video information in 16:9 aspect ratio. Since the transmitter 22 is not included in the FIGURE 3 camcorder, the compression-encoded-audio decoder 23 is omitted. The FIGURE 3 camcorder has a liquid-crystal-display (LCD) viewfinder 225 with a viewscreen having 16:9 aspect ratio. The compression-encoded-video decoder 24 is retained, to generate decompressed video signal for viewfinder drive circuitry. During playback (or recording and playback), viewfinder drive circuitry 226 can supply drive signals to the LCD viewfinder 225 in response to Y, Cr, and Cb signals in 4:2:0 sampling format supplied by the decoder 24. During recording or previewing, viewfinder drive circuitry 226 can supply drive signals to the LCD viewfinder 225 in response to Y, Cr, and Cb signals in 4:2:0 sampling format supplied by the video input processor 202. The drive signals applied to the LCD viewfinder 225 are typically R, G and B drive signals.

A low-power NTSC television transmitter is used

- 24 -

in a variant of the FIGURE 3 camcorder, with arrangements to transmit the 16:9 aspect ratio video images in letter-box format. In such variant the compression-encoded-audio decoder 23 is retained.

5 FIGURE 4 shows a camcorder that differs from the FIGURE 3 camcorder in the way that trickplay is implemented. The DCT blocks are recorded in the tracks on the electromagnetic tape so that the zero-frequency and other low-frequency DCT coefficients of the
10 succession of DCT blocks of each frame occupy leading portions of syncblocks. During trickplay these zero-frequency and other low-frequency DCT coefficients are recovered for generating a low-resolution display, and the higher-frequency DCT coefficients are discarded.
15 With twenty tracks being read in parallel, eliminating the trickplay bands conventionally used in digital video cassette recording increases the average payload data rate from 38.6 million bits per second to 46 million bits per second.

20 The trickplay extraction circuitry 204 is omitted in the FIGURE 4 camcorder, and the video compression apparatus 203 is replaced by video compression apparatus 303 which need not include provisions to facilitate connection to the trickplay
25 extraction circuitry 204. In the FIGURE 4 camcorder the data-frame assembler 6 is replaced by the data-frame assembler 106, which omits syncblocks descriptive of trickplay bands from its transport stream assembly procedures and increases the number of syncblocks
30 containing normal-play video packet information in each frame. The data-frame assembler 106 shuffles the order of the DCT coefficients of the succession of DCT blocks of each frame so the direct or zero-frequency DCT

coefficient and other low-frequency DCT coefficients occupy leading portions of syncblocks. The Reed-Solomon error correction encoder 9 and the Reed-Solomon error correction decoder 13 are replaced by the Reed-Solomon error correction encoder 109 and the Reed-Solomon error correction decoder 113, respectively, because of the increased number of video syncblocks in an error-correction-coding data frame. The data-frame disassembler 16 is replaced by the data-frame disassembler 116 that takes into account the reproduced transport stream omitting syncblocks descriptive of trickplay bands and replacing the omitted syncblocks with syncblocks containing further video packet information.

FIGURE 5 shows a video recording and reproduction system in which video compression is done in accordance with the invention. The system is constructed around a digital videocassette recorder (and player), or DVCR, 400 including a component magnetic tape recorder and player 413. The recorder and player 413 can be used for playback from the magnetic tape in a digital videocassette recorded by one of the camcorders of FIGURES 1, 2, 3 and 4. In fact, a digital videocassette recorded by the FIGURE 1 camcorder is suitable for playing on a standard-density (SD) digital television tape recorder and player, or on an SD digital television tape player, without modification of the playback electronics. Elements 402 - 424 of the DVCR 400 substantially correspond to elements 2 - 24, respectively, of the FIGURE 1 camcorder, both as to structure and individual operation. The DVCR 400 differs from a conventional SD DVCR, being modified to include the video input processor 402, the video compression apparatus 403, the

- 26 -

trickplay data extraction circuitry 404, the time stamp counter 405, the audio encoding apparatus 408, the transport stream encoders 410 and 419, the transport stream selector 411, the audio and video selector 417, the transport stream decoder 418, the IEEE 1394 signal assembler, the compressed audio decoder 423 and the compressed video decoder 424. The data-frame assembler 406 with ECC encoders and the data-frame disassembler 416 with ECC decoders are modified from those used in an SD DVCR, to make allowance for the inclusion of trickplay syncblocks in each data frame that is recorded. The 24/25 I-NRZI modulator 412, the 24/25 I-NRZI demodulator 414, the low-power NTSC television transmitter 422 and the NTSC television receiver front end 427 are substantially the same as in an SD DVCR.

The video input processor 402 selects video information to be compressed from an NTSC analog television receiver 430 outside the DVCR 400, from a personal computer 440 outside the DVCR 400, or from a television receiver front end 427 within the DVCR 400. The video information selected by video input processor 402 for compression is converted to a luminance signal *Y*, a red-minus-luminance color difference signal *Cr*, and a blue-minus-luminance color difference signal *Cb* in 4:2:0 sampling format for application to the video compression apparatus 403. The video information from the television receiver front end 427 comprises a luminance signal *Y*, a red-minus-luminance color difference signal *Cr*, and a blue-minus-luminance color difference signal *Cb* in 4:2:2 sampling format. The *Y*, *Cr*, and *Cb* signals are converted to 4:2:0 sampling format by performing a 2:1 decimation in both the vertical and the horizontal directions after lowpass anti-aliasing filtering.

- 27 -

FIGURE 5 shows the video information from the personal computer 440 being supplied as a red signal R, a green signal G and a blue signal B. FIGURE 5 shows the video information from the analog television receiver 430 being supplied as a luminance signal Y and orthogonal color difference signals Cr and Cb. Alternatively, video information can be supplied from the analog TV receiver 430 as a further red signal R, a further green signal G and a further blue signal B.

10 The video input processor 402 includes color matrixing circuitry (not explicitly shown) for converting R, G and B video signals to Y, Cr and Cb video signals, which are then converted to 4:2:0 sampling format by performing suitable decimations in both the vertical

15 and the horizontal directions after lowpass anti-aliasing filtering. In yet another alternative arrangement, video information can be supplied from the analog TV receiver 430 as a luminance signal Y and orthogonal color difference signals I and Q. The video

20 input processor 402 will then be modified to include color matrixing circuitry for converting I and Q video signals to Cr and Cb video signals.

In FIGURE 5 the video compression apparatus 403 has trickplay data extraction circuitry 404 associated

25 therewith. The data-frame assembler 406 with ECC decoders is designed to place the trickplay data into selected syncblocks with prescribed locations within each data frame. The time stamp counter 405 counts system clock cycles in each group of sixteen video

30 frames, to provide time stamp information to the video compression apparatus 403, to the IEEE 1394 signal encoder 420, and to the transport stream encoders 410 and 419. The audio encoding apparatus 408 within the DVCR 400 of FIGURE 5 performs compression encoding of

left-channel (L) and right-channel (R) signal signals from the NTSC television receiver 430, from the personal computer 440, or from the NTSC television receiver front end 427 within the DVCR 400.

5 Responsive to a control setting by a user of the FIGURE 5 DVCR 400, an operating mode control 409 conditions the DVCR to operate in accordance with a first data-frame-assembly mode. In this first data-frame-assembly mode the compressed video information
10 from the video compression apparatus 403 and the compressed audio information from the audio encoding apparatus 408 are utilized directly by the data-frame assembler 406.

 The operating mode control 409 can
15 alternatively have a user control setting that conditions the FIGURE 5 DVCR for operation in accordance with a second data-frame-assembly mode. In this second data-frame-assembly mode a transport stream supplied from the
20 transport stream encoder 410 is utilized as input signal by the data-frame assembler 406, rather than the compressed video information supplied directly from the video compression apparatus 403 and the compressed audio information from the audio encoding apparatus
25 408. The transport stream encoder 410 parses the compressed video information into pairs of consecutive MPEG-2 video packets preceded by packet headers identifying them as video packets. The transport stream encoder 410 parses the compressed audio
30 information into audio packets preceded by packet headers identifying them as audio packets. The transport stream encoder 410 assembles the video and audio packets into a first transport stream supplied to

- 29 -

a transport stream selector 411. The transport stream encoder 410 also assembles a second transport stream differing from the first transport stream in that extra time stamps as extracted from the time stamp counter 405 are inserted. This is done to implement 2:5 conversion, in which each consecutive pair of the 188-byte packets in this second transport stream are written into five rows of the memory in the data-frame assembler 406, for subsequent reading as five sync blocks from the assembler 406.

The operating mode control 409 can alternatively have a user control setting that conditions the FIGURE 5 DVCR for operation in accordance with a third data-frame-assembly mode. In this third data-frame-assembly mode the response of an IEEE 1394 signal decoder 428 to an IEEE 1394 signal supplied to the DVCR 400 supplies the transport stream accepted as input signal by the data-frame assembler 409. The IEEE 1394 signal decoder 428 eliminates the IEEE 1394 headers to recover an MPEG-2 transport stream. The decoder 428 inserts extra time stamps secured from the time stamp counter 405 into the recovered MPEG-2 transport stream. This implements 2:5 conversion of the transport stream when it is subsequently loaded into the data-frame assembler 409.

After error correction coding is completed by the ECC encoders in the data-frame assembler 409, sync blocks are read from from the assembler 409 to a 24/25 modulator 412 as a modulating signal that governs the generation of interleaved-NRZI modulation. This I-NRZI modulation is supplied to the recording amplifier of a magnetic tape

- 30 -

recorder (and player) 413 in the VCR 400.

During videocassette playback and during the monitoring of videocassette recording, a playback amplifier in the VCR 400 supplies 24/25 I-NRZI modulation to the 24/25 I-NRZI demodulator 414, which reproduces the error-correction-coded syncblocks supplied from the data-frame assembler 406 for recording. During the monitoring of videocassette recording, the recorder bypass switch 415 is set in response to the desire of a user to select error-correction-coded syncblocks to the data-frame disassembler 416 either from the data-frame assembler 406 or from the 24/25 I-NRZI demodulator 414.

The data-frame disassembler 416 corrects errors in the signal supplied thereto and accordingly includes decoders for the Reed-Solomon forward error-correction-codes. The data-frame disassembler 416 includes temporary-storage memory for video, which memory is operated as an interleaver for the video ECC decoder. The data-frame disassembler 416 also includes temporary-storage memory for audio, which memory is operated as an interleaver for the audio ECC decoder.

When the user control setting of the operating mode control 409 selects normal play in accordance with the first data-frame-assembly mode, the audio/video selector 417 selects as its output signal compressed video information and compressed audio information read from respective temporary-storage memory in the data-frame disassembler 416. The compressed video information and compressed audio information are read to the audio/video selector 417 after the ECC decoders in the data-frame disassembler 16 complete error

correction of the information. In this mode the compression-encoded-video decoder 424 decodes compressed video information from the audio/video selector 417 on an I-frame-only basis. If the
5 compression-encoded-video decoder 424 has the capability of decoding B or P frames as well as I frames, the decoder 424 is conditioned to decode on an I-frame-only basis responsive to the picture headers in the compressed video signal.

10 When the user control setting of the operating mode control 409 selects

normal-play in accordance with the second or third data-frame-assembly mode, the audio/video selector 417 selects as its output signal compressed video
15 information and compressed audio information supplied by a transport stream decoder 418. The compressed video information and compressed audio information are decoded from video packets and audio packets read to the decoder 418 from respective temporary-storage
20 memory in the data-frame disassembler 416. The video packets and audio packets are read to the transport stream decoder 418 after error correction of the packets by the ECC decoders in the data-frame disassembler 416 has been completed. If the
25 compression-encoded-video decoder 424 has the capability of decoding B or P frames as well as I frames, the decoder 424 is conditioned to decode on an I-frame-only basis responsive to the picture headers in the compressed video signal indicating that this was
30 the mode in which the DVCR tape cassette being played back was recorded.

When the user control setting of the operating mode control 409 selects trickplay, the output signal

- 32 -

that the audio/video selector 417 supplies comprises null compressed audio information supplied as wired input and compressed video information recorded as trickplay signal, then read from temporary-storage
5 memory in the data-frame disassembler 416 during playback. The audio recovered by the compression-encoded-audio decoder 423 is muted. If the compression-encoded-video decoder 424 has the capability of decoding B or P frames as well as I
10 frames, the decoder 424 is conditioned to decode on an I-frame-only basis responsive to the user control setting of the operating mode control 409.

The compressed video information and compressed audio information the audio/video selector 417 selects
15 as its output signal is supplied to a transport stream encoder 419. The transport stream encoder 419 supplies the transport stream selector 411 with a transport stream that is available during normal play in accordance with the first data-frame-assembly mode.
20 The transport stream selector 411 responds to control setting by the user of the FIGURE 1 camcorder either to reproduce in its output signal the transport stream before recording, as supplied thereto by the transport stream encoder 410, or another transport stream after
25 playback from the tape recorder 413. The transport stream selector 411 automatically selects the output signal from the transport stream encoder 419 as this other transport stream responsive to the operating mode control 409 selecting playback in accordance with the
30 first data-frame-assembly mode. Responsive to the operating mode control 409 selecting playback in accordance with the second data-frame-assembly mode, the transport stream selector 411 automatically selects

- 33 -

the output signal from the data-frame disassembler 416 to the transport stream decoder 418 as the other transport stream after playback that the selector 421 can reproduce as its output signal.

5 In a variation from what is shown in FIGURE 5 that does not alter ultimate camcorder performance very much, the other transport stream after playback from the tape recorder 413 can always be the output signal from the transport stream encoder 419.

10 The transport stream reproduced in the output signal of the transport stream selector 411 is supplied to an IEEE 1394 signal encoder 420. The IEEE 1394 signal encoder 420 prefaces each 188-byte packet in the transport stream with a 4-byte time stamp, apporitions
15 each 192-byte time-stamped packet among shorter data blocks (e. g., each of 96-byte length), and precedes each data block with a header for accessing the transmission line and a CIP header. FIGURE 5 shows the IEEE 1394 si from the IEEE 1394 signal encoder 420
20 being supplied to the personal computer 440 and to the digital video disk recorder and player 450 as respective input signals to them. FIGURE 5 shows the personal computer 440 arranged for connection with another computer (not explicitly shown) via a packet
25 communications link - for example, the internet. The personal computer 440 can also be connected through a server to other types of terminal.

FIGURE 5 also shows the low-power NTSC television transmitter 422 transmitting a radio-
30 frequency signal to the analog television receiver 430. More particularly, the compression-encoded-audio decoder 423 supplies audio signals to the transmitter 422 to be combined to form a signal for modulating the

frequency of the audio carrier supplied by the transmitter 422. And the compression-encoded-video decoder 424 supplies video signals to be combined to form a composite video signal for modulating the amplitude of the video carrier supplied by the transmitter 422. Since it is desirable to be able to play digital videotape recordings with MPEG-2 coded video, the compressed video decoder 424 is preferably a conventional MPEG-2 video decoder.

10 The DVCR 400 provides a convenient way for consolidate audio and visual material in a form lending itself to editing with the aid of the personal computer 440 that is appropriately programmed, that has provisions for monitoring the material to be edited, and that is provided with a storage medium that can store a long sequence of pictures. Various video tape recordings made with a camcorder of the type shown in FIGURE 1 can be consolidated in a single digital video cassette tape for playback to the personal computer 440. Consolidated material can also include or consist of television programming received by the television receiver 430 off the air, from cable, from the digital video disk (recorder and) player 450 or from another digital video recorder. After editing, the DVCR 400 provides a way for recording edited material, as furnished to it from the personal computer 440.

FIGURE 6 shows another video recording and reproduction system in which video compression is done in accordance with the invention, differing from that of FIGURE 5 in the way that trickplay is implemented. In the digital videocassette recorder (and player) 500 of FIGURE 6, the DCT blocks are recorded in the tracks on the electromagnetic tape so that the zero-frequency

- 35 -

and other low-frequency DCT coefficients of the succession of DCT blocks of each frame occupy leading portions of synchlocks, to avoid the need for trickplay bands in the video recording portions of the magnetic tape recording. The FIGURE 6 DVCR 500 is suitable for playing videocassettes recorded by the FIGURE 2 camcorder.

The FIGURE 6 DVCR 500 differs from the FIGURE 5 DVCR 400 in not having trickplay data extraction circuitry 404. The data-frame assembler 406 is replaced by a data-frame assembler 506, which omits synchlocks descriptive of trickplay bands from its data frame assembly procedures and increases the number of synchlocks containing normal-play video packet information in each frame. The data-frame assembler 506 includes circuitry for shuffling the order of the DCT coefficients of the succession of DCT blocks of each frame so the direct or zero-frequency DCT coefficient and other low-frequency DCT coefficients occupy leading portions of synchlocks. The compressed video detector 424, which can be a standard MPEG-2 compressed video decoder, is replaced by a compressed video detector 524 that additionally includes capability for extracting trickplay information from the zero-frequency DCT coefficient and other low-frequency DCT coefficients that occupy leading portions of synchlocks in the digital videotape recordings made in accordance with the aspect of the invention embodied in the FIGURE 6 DVCR 500.

FIGURE 7 shows a modification of the FIGURE 5 system that uses an advanced digital videocassette recorder (and player) 600 capable of recording progressively scanned frames of video information

including luminance (Y) information having 720 active scan lines in each frame and 1280 pixels in each scan line, as supplied by a video camera 601 for responding to images in 16:9 aspect ratio or from another source.

5 One other source is a digital television receiver front end 627 with elements up top and including a packet sorter that is included within the DVCR 600. Other sources are a digital television receiver 630 and a personal computer 640 located outside the DVCR 600. A

10 video input processor 602 processes the progressively scanned frames of video information from a selected one of these sources to generate Y, Cr, and Cb signals in 4:2:0 sampling format. Video compression apparatus 603 receives the Y, Cr, and Cb signals in 4:2:0 sampling

15 format including luminance (Y) information having 720 active scan lines in each frame and 1280 pixels in each scan line. Compressive encoding of these signals is carried out by video compression apparatus 603 on an intraframe basis on every one of the frames, in

20 accordance with the same intraframe compression encoding protocol used on only the first, anchor frame of each group of pictures in MPEG-2 video compression encoding. Trickplay extraction circuitry 604 is

25 substantially the same as trickplay extraction circuitry 404 of FIGURE 4 except for taking the different viewscreen aspect ratio into account. Audio encoding apparatus 608 differs from the audio encoding apparatus 408 of FIGURE 4 in that it has the capability of accepting AC-3 audio packets from the digital

30 television receiver 630 for selective transfer to the transport stream encoder 410.

The amount of compressed video data is increased in the FIGURE 7 DVCR 600 as compared to the FIGURE 5 DVCR 400, owing to the increased number of pixels per

- 37 -

frame. So the compressed high-definition video information in each frame is permitted to occupy twenty recording tracks on the magnetic video tape in the FIGURE 7 DVCR 600, rather than just the ten tracks
5 allotted to each frame of standard definition video information in the FIGURE 5 DVCR 400.

The IEEE 1394 Standard signal from the IEEE 1394 signal encoder 420 is supplied as an output signal from the ATV tape recorder and player 600 applied in FIGURE
10 7 to the personal computer 630 and to a digital video disk recorder and player 650. FIGURE 7 shows the personal computer 630 arranged for connection with another computer (not explicitly shown) via a packet communications link - for example, the internet. The
15 personal computer 630 can also be connected through a server to other types of terminal. The digital video disk recorder and player 650 is arranged to supply its output signal to the DTV receiver 630 for viewing.

FIGURE 7 shows the DVCR 600 including a low-
20 power ATSC digital television transmitter 622 connected for transmitting ATSC digital television signal to the DTV receiver 630 in response to transport stream received from the transport stream selector 411.

FIGURE 8 shows another video recording and
25 reproduction system in which video compression is done in accordance with the invention, using an advanced digital television tape recorder and player 700 differing from the ATV tape recorder and player 600 of FIGURE 7 in the way that trickplay is implemented. In
30 the ATV tape recorder and player 700 of FIGURE 8, the DCT blocks are recorded in the tracks on the electromagnetic tape so that the zero-frequency and other low-frequency DCT coefficients of the succession

of DCT blocks of each frame occupy leading portions of synchlocks, to avoid the need for trickplay bands in the video recording portions of the magnetic tape recording. In the ATV tape recorder and player 700 of
5 FIGURE 8, the trickplay data extraction circuitry 606 is dispensed with and the data-frame assembler 406 is replaced by a data-frame assembler 506, which omits synchlocks descriptive of trickplay bands from its data-frame assembly procedures and increases the number
10 of synchlocks containing normal-play video packet information in each frame. The data-frame assembler 506 shuffles the order of the DCT coefficients of the succession of DCT blocks of each frame so the direct or zero-frequency DCT coefficient and other low-frequency
15 DCT coefficients occupy leading portions of synchlocks. The data-frame disassembler 416 is replaced by the data-frame disassembler 516, because of the increased number of video synchlocks in an error-correction-coding data frame.

20 FIGURE 9 shows a modification 800 of the FIGURE 7 DVCR 600. In this modified DVCR 800 of FIGURE 9, the DTV front end 627 up to and including the packet sorter is replaced by a DTV front end 827 further including an MPEG-2 decoder for compressed video (and possibly
25 audio) information and an AC-3 decoder for compressed audio information. The DVCR 800 comprises an operating mode control 809 having user control settings that conditions the FIGURE 9 DVCR for operation in accordance with a first data-frame-assembly mode in
30 which compressed video and audio information from the video compression apparatus 603 and from the audio encoding apparatus 608 are recorded without being encoded in a transport stream, a second data-frame-assembly mode in which the transport stream generated

- 39 -

by the transport stream encoder 410 is recorded, a third data-frame-assembly mode in which the transport stream generated by the IEEE 1394 signal decoder 428 is recorded, and a fourth data-frame-assembly mode in which compressed video and audio information from the DTV front end 827 are recorded without being encoded in a transport stream.

FIGURE 10 shows a modification 900 of the FIGURE 8 DVCR 700 of FIGURE 8. In this modified DVCR 900 of FIGURE 10, the DTV front end 627 up to the packet sorter is replaced by a DTV front end 827 including an MPEG-2 decoder in addition to the packet sorter. The DVCR 900 also replaces the operating mode control 409 with the operating mode control 809.

In variants of the DVCRs 600 and 800, the transport stream from the disassembler 406, rather than the transport stream from the transport stream selector 411, is supplied to the low-power ATSC DTV transmitter 622 as input signal. In variants of the DVCRs 700 and 900, the transport stream from the disassembler 406, rather than the transport stream from the transport stream selector 411, is supplied to the low-power ATSC DTV transmitter 622 as input signal. The low-power ATSC DTV transmitter 622 in any of the DVCRs 600, 700, 800 and 900 can be viewed as providing a wired microwave link to the DTV receiver 430. This can be replaced by a microwave link using through-the-air transmission at television broadcast frequencies. A similar microwave link can be established between the camcorder of FIGURE 3 or 4 and the DTV receiver front end 627 of the DVCR 600 or 700. A similar microwave link can also be established between the camcorder of FIGURE 3 or 4 and the DTV receiver front end 827 with MPEG-2 and AC-3

decoders of the DVCR 800 or 900. In professional apparatus the microwave transmission and reception frequencies can be in a band higher in frequency than that used for television broadcasting, and scrambling of the transmitted data is possible.

FIGURE 11 shows in greater detail the circuitry for compressing video and generating a transport stream used in the FIGURE 1 camcorder. Similar circuitry is used in the FIGURE 3 camcorder and in the digital tape recorders 400, 600 and 800 of FIGURES 5, 7 and 9. An input buffer memory 30, DCT computation circuitry 31, quantizer circuitry 32, activity calculation circuitry 33, quantizing table selection circuitry 34, an entropy encoder 35, a multiplexer 36 and an encoder output buffer memory 37 shown in FIGURE 11 are elements of the video compression apparatus 3 of FIGURE 1. In practice, the DCT computation circuitry 31, quantizer circuitry 32 and activity calculation circuitry 33 may be implemented using a microprocessor. A compressed-video-signal packer 38 of FIGURE 11 is associated with the transport stream encoder 10 of FIGURE 1, and a compressed-video-signal packer 39 of FIGURE 11 is associated with the data-frame assembler 6 of FIGURE 1. A trickplay output buffer memory 40 of FIGURE 11 is included within the trickplay data extraction circuitry 4 of FIGURE 1. A compressed-video-signal packer 41 of FIGURE 11 is associated with the data-frame assembler 6 of FIGURE 1.

Video input comprising Y, Cr, and Cb signals in 4:2:0 sampling format is loaded into the input buffer memory 30, which stores somewhat more than a frame of samples and permits image blocks eight luma pixels square to be considered one after the other. DCT

- 41 -

computation circuitry 31 computes DCT coefficients for the Y, Cr, and Cb components of each successively considered image block, normalizing the higher-order DCT coefficients with regard to the zero-frequency DCT coefficient and supplying the computed DCT coefficients in zigzag scanning order to the quantizer circuitry 32.

The activity calculation circuitry 33 estimates the degree of activity in the image. First, the average value of the pixels in each DCT block is calculated. Then, the difference between the value of each pixel in each DCT block and its average value is determined, and the differences are squared. The squared differences are accumulated for each block, and the resulting sum is normalized by dividing it by the number of pixels per block. The normalized sums for all the DCT blocks in a frame are accumulated, the accumulation result for the frame is multiplied by a first constant value A, and the resulting product has a second constant value B added to it determine the activity in the frame, which directly relates to an estimation of the number of bits in the entropy coding of the frame.

This measure of activity in the frame is supplied to quantization table selection circuitry 34, which uses this measure for selecting the initial table of quantizing values for the DCT coefficients that the circuitry 34 supplies to the quantizer circuitry 32. The quantization table selection circuitry 34 supplies a code identifying the table of quantizing values for the DCT coefficients that the circuitry 34 supplies to the quantizer circuitry 32. The quantized DCT coefficients supplied from the quantizer circuitry 32 are supplied to an entropy encoder 35, sometimes

- 42 -

referred to as a "Huffman encoder" for lossless coding including steps of run-length coding and variable-length coding.

A multiplexer 36 receives the entropy encoding
5 results from the entropy encoder 35 and also receives the codes identifying the tables of quantizing values for the DCT coefficients that the circuitry 34 supplies to the quantizer circuitry 32. Whenever there is immediately to be a change in the table of quantizing
10 values the quantizer circuitry 32 uses, the multiplexer 36 inserts the code identifying the table next to be used into the codestream it supplies as its output signal. The inserted code serves as a prefix for the entropy encoding results from the entropy encoder 35
15 that are then reproduced in the codestream the multiplexer 36 supplies as its output signal.

An encoder output buffer memory 37 of a first-in/first-out type temporarily stores the codestream the multiplexer 36 supplies as its output
20 signal. The buffer memory 37 has storage capacity for a fraction (e. g., one-quarter) of the amount of code acceptable in a video frame and signals the quantization table selection circuitry 34 when enough of that storage capacity is used to risk overfilling.
25 Responsive to such signaling, the quantization table selection circuitry 34 selects a quantization table to be used by the quantizer circuitry 32 in order to reduce its rate of bit production. When the storage capacity of the buffer memory 37 is substantially
30 under-utilized for a period of time, the quantization table selection circuitry 34 is signaled to select a quantization table to be used by the quantizer circuitry 32 in order to increase its rate of bit

production. This reduces the likelihood of the buffer memory 37 being emptied and thereby avoids the need to use null codes in the codestream supplied from the buffer memory 37 to the compressed-video-signal packers 5 38 and 39.

The compressed-video-signal packer 38 parses the codestream supplied from the buffer memory 37 into (184-n)-byte video packet payload lengths and prefaces each video packet payload with a respective video 10 packet header. This video packet header includes an I frame flag code. The video packets are incorporated within the transport stream supplied from the transport stream encoder 10 to the data-frame assembler 6. In the data-frame assembler 6, as part of a 2:5 conversion 15 procedure, the video packets are inserted into prescribed sync blocks of each data frame being assembled for recording and then are subjected to two-dimensional Reed-Solomon encoding.

The compressed-video-signal packer 39 parses the 20 codestream supplied from the buffer memory 37 into 77-byte segments for direct insertion into temporary memory within the data-frame assembler 6 at prescribed sync block locations of a data frame being assembled. The 77-byte segments are subsequently subjected to 25 two-dimensional Reed-Solomon encoding procedures within the data-frame assembler 6.

The trickplay output buffer memory 40 is of random-access type and temporarily stores zero- and low-frequency DCT components from the codestream the 30 multiplexer 36 supplies as its description of each sixteenth image frame. Different portions of the contents of the trickplay output buffer memory 40 are

read out at various times to the compressed-video-signal packer 41 to be formed into bytes and inserted by the data-frame assembler 6 into prescribed sync blocks of each data frame assembled for recording.

5 FIGURE 12 shows in greater detail the circuitry for compressing video and generating a transport stream used in the FIGURE 2 camcorder. Similar circuitry is used in the FIGURE 4 camcorder and in the digital tape recorders 500, 700 and 900 of FIGURES 6, 8 and 10. The
10 input buffer memory 30, DCT computation circuitry 131, the quantizer circuitry 32, the activity calculation circuitry 33, quantizing table selection circuitry 134, the entropy encoder 35, the multiplexer 36, an encoder output buffer memory 1371 for codestream coding zero-
15 and low-frequency DCT coefficients, and an encoder output buffer memory 1372 for codestream coding high-frequency DCT coefficients shown in FIGURE 12 are elements of the video compression apparatus 103 of FIGURE 2. In practice, the DCT computation circuitry
20 131, quantizer circuitry 32 and activity calculation circuitry 33 may be implemented using a microprocessor. A compressed-video-signal packer 138 of FIGURE 12 is associated with the transport stream encoder 110 of FIGURE 2, and a
25 compressed-video-signal packer 139 of FIGURE 12 is associated with the data-frame assembler 106 of FIGURE 2.

 The transport stream generated by the transport stream encoder 110 comprises video and audio packets,
30 and is characterized by the video packets being formed with the codes descriptive of the zero- and low-frequency DCT coefficients immediately after syncblock

headers, so as to facilitate trickplay.

The DCT computation circuitry 131 is implemented so as to provide an ENCODING MODE INDICATION indicative of whether the computation results are low-frequency
5 DCT coefficients (including zero-frequency coefficients) or are

high-frequency DCT coefficients. When the ENCODING MODE INDICATION indicates that the computation results are zero- or low-frequency DCT coefficients, the buffer
10 memory 1371 is conditioned to store the computation results, and the quantizing table selection circuitry 134 conditions the quantizer 32 to apply quantizing tables for the zero- or low-frequency DCT coefficients. When the ENCODING MODE INDICATION indicates that the
15 computation results are

high-frequency DCT coefficients, the buffer memory 1372 is conditioned to store the computation results, and the quantizing table selection circuitry 134 conditions the quantizer 32 to apply quantizing tables for the
20 high-frequency DCT coefficients.

The buffer memory 1371 is a first-in/first-out memory for storing two parallel bitstreams. One of the bitstreams composed of the entropy code and quantizing table code associated with the zero- and low-frequency
25 DCT coefficients. The other bitstream is composed of markers indicating breaks between DCT blocks in the computation of the zero- and low-frequency DCT coefficients. The markers facilitate the compressed-video-signal packers 138 and 139 arranging the codes
30 descriptive of the zero- and low-frequency DCT coefficients in bit ranges immediately after syncblock headers. These bit ranges extend for prescribed

intervals or somewhat longer. The compressed-video-signal packer 138 in the transport stream encoder 110 makes allowance in its packing for the transport stream headers and extra time stamps being included in the transport stream before its being parsed into syncblocks in the data-frame assembler 110. The compressed-video-signal packer 139 used in the data-frame assembler 106 for recording compressed video signal that is not converted to transport stream format performs its packing without such allowance being made nor having to be made. When a marker first occurs after a prescribed interval following syncblock header, each of the compressed-video-signal packers 138 and 139 discontinues packing code from the buffer memory 1371 and begins to pack code from the buffer memory 1372 instead. Packing code from the buffer memory 1372 then continues until the end of the syncblock is reached. The quantizing table selection circuitry 134 receives a first rate control signal from the buffer memory 1371 and a second rate control signal from the buffer memory 1372 for controlling the selection of quantization tables, so that quantization tables can be chosen to keep the amount of information each buffer memory stores within prescribed limits.

FIGURE 13 indicates how in a modification of the DVCR 400 of FIGURE 5 or of the DVCR 500 of FIGURE 6 an MPEG-2 decoder 43 is conditioned for functionally replacing the video compression apparatus 403 for generating consecutive I frames only, by providing a source 44 of the selective command for the MPEG-2 decoder 43 to encode all sequential frames as I frames rather than just anchor frames. FIGURE 13 also indicates, in parentheses, how in a modification of the digital tape recorder and player of FIGURE 7, 8, 9 or

- 47 -

10 an MPEG-2 decoder 63 is conditioned for functionally replacing the video compression apparatus 603 for generating consecutive I frames only, by providing a source 64 of the selective command for the MPEG-2
5 decoder 63 to encode all sequential frames as I frames rather than just the anchor frames.

FIGURE 14 shows snapshot apparatus 50 suited for use with the camcorder of FIGURE 1 or 2, or with the digital tape recorder and player of FIGURE 5
10 or 6. The snapshot apparatus 50 includes a IEEE 1394 signal decoder 51 for the IEEE 1394 Standard signal supplied from the IEEE 1394 signal encoder 20 or 420, an MPEG-2 decoder 52 for decoding video packets supplied from the decoder 51, a frame grabber 53 for
15 NTSC video frames, and a printer 54 for producing a hard copy reproduction of the grabbed NTSC video frame. The frame grabber 53 is a memory for snatching from a continuous stream of digital video signal samples those data descriptive of a single selected frame of video
20 and, by way of example, employs a small magnetic disk memory. A modified MPEG-2 decoder only for I frames can be used in the snapshot apparatus 50.

FIGURE 15 shows snapshot apparatus 55 suited for use with the camcorder of FIGURE 3 or 4, or with the
25 digital tape recorder and player of FIGURE 7 or 8. The snapshot apparatus 55 includes an IEEE 1394 signal decoder 56 for the IEEE 1394 Standard signal supplied from the IEEE 1394 signal encoder 20 or 420, an MPEG-2 decoder 57 for decoding video packets supplied from the
30 decoder 56, a frame grabber 58 for ATSC video frames, and a printer 59 for producing a hard copy reproduction of the grabbed ATSC video frame. A modified MPEG-2 decoder only for I frames can be used in the snapshot

apparatus 55.

FIGURE 16 shows a system including a digital camcorder 1000, a computer 1040 with video and audio editing software, and one of the DVCRs 400, 500, 600, 700, 800 and 900. If the DVCR 400 or 500 is used, the digital camcorder 1000 can be of the sort shown in FIGURE 1 or 2. If the DVCR 600, 700, 800 and 900 is used, the digital camcorder 1000 can be of the sort shown in FIGURE 3 or 4. The IEEE 1394 Standard output signal of the digital camcorder 1000 is supplied to the computer 1040 which should have storage capability for appreciably long sequences of frames.

Generally video editing is done first, after video and audio data are separated to separate memories. After video editing is completed, audio editing can then be done. This avoids editing interrupting the audio signal at inopportune times - e. g., in the mid-sentence of an interview. During the process of video editing, the software in the computer 1040 stores the time stamp information of deleted video material, so the editor will know which audio packets need to be evaluated during the deferred audio editing procedures.

The computer 1040 can be supplied additional material to be used in editing by means additional to the camcorder 1000. For example, arrangements can be made to allow the computer 1040 to additively mix background music or voice-over with audio decoded from a compressed audio signal recorded at the time digital video was being produced by a video camera. Keyboard input to the computer 1040 can be used to help implement the insertion of titling or captions into the compressed video. Computer graphics packages can be

- 49 -

used to improve titling. Arrangements can be made to decode compressed video, to perform special-effects operations on the decoded video in the computer 1040, and to compress the processed video. These

5 arrangements allow video editing other than jump cuts - e. g., fades through black, wipes and iris effects. The finally edited information is then placed into IEEE 1394 Standard signal format by the computer 1040 to be supplied to the IEEE 1394 signal input of the DVCR 400,

10 500, 600, 700, 800 or 900 which DVCR records the finally edited information on a video diskette.

One skilled in the art will be enabled by the foregoing description and the accompanying drawing readily to construct other embodiments of the invention

15 that are equivalent to those specifically described; and the claims which follow should be construed to include obvious design variations within their scope. For example,

error-correction coding of components of the transport

20 stream can be performed at least in part before assembling the transport stream from its component parts. By way of further example, error-correction decoding of components of the transport stream can be performed at least in part after disassembling the

25 transport stream into its component parts. As still further example, other means for recording on an optical medium such as a compact disk recorder and player may replace the digital video disk recorder and player. In the claims which follow, the term "MPEG-2

30 decoder" is to be construed to apply to a complete MPEG-2 decoder, capable of decoding P and B frames as well as I frames, and also to apply to modifications of such decoder that decode only I frames.

What is claimed is:

1. A method for transmitting compressed video information, comprising the steps of:

5 generating a succession of line-interlaced raster-scanned frames of video information as luminance signal and first and second color-difference signals in a 4:2:0 sampling format;

10 intraframe compression encoding each line-interlaced raster-scanned consecutive frame of video information, in accordance with the MPEG-2 standard that conventionally is used for intraframe compression of only selected ones of said consecutive frames of video information, thereby to generate components of a transport stream.

15 2. The method of claim 1 including the further step of:

in accordance with the MPEG-2 standard, inserting into said transport stream codes identifying each said consecutive frame of video information as being
20 intraframe compression encoded.

3. The method of claim 1 including the further step of:

recording said transport stream on a magnetic storage medium.

4. The method of claim 1 including the further steps

of:

extracting trickplay information from each frame
of video information for insertion into said transport
5 stream, and

recording on a magnetic storage medium said
transport stream with said trickplay information inserted
therein.

10 5. The method of claim 1 including the further steps
of:

arranging zero-frequency and low-frequency DCT
information at the beginnings of sync blocks in said said
transport stream, and

15 recording on a magnetic storage medium said
transport stream as so arranged.

6. The method of claim 1 including the further step
of:

20 recording said transport stream on an optical
disk. medium.

7. The method of claim 1 including the further step
of:

25 transmitting said transport stream over a
microwave link.

8. The method of claim 1 including the further step
of:

30 transmitting said transport stream from one
computer to another via a packet communications link.

9. The method of claim 1 including the further step
of:

35 editing said transport stream using a computer.

10. A method for transmitting compressed video
information, comprising the steps of:

40 generating a succession of progressively scanned
frames of video information as luminance signal and first
and second color-difference signals in a 4:2:0 sampling
format;

45 intraframe compression encoding each progressively
scanned consecutive frame of video information, in
accordance with the MPEG-2 standard that conventionally
is used for intraframe compression of only selected ones
of said consecutive frames of video information, thereby
to generate components of a transport stream.

50 11. The method of claim 10 including the further step
of:

55 in accordance with the MPEG-2 standard, inserting
into said transport stream codes identifying each said
consecutive frame of video information as being
intraframe compression encoded.

12. The method of claim 10 including the further step
of:

60 recording said transport stream on a magnetic storage medium.

13. The method of claim 10 including the further steps of:

65 extracting trickplay information from each frame of video information for insertion into said transport stream

recording on a magnetic storage medium said transport stream with said trickplay information inserted therein.

70 14. The method of claim 10 including the further steps of:

arranging zero-frequency and low-frequency DCT information at the beginnings of sync blocks in said said transport stream, and

75 recording on a magnetic storage medium said transport stream as so arranged.

15. The method of claim 10 including the further step of:

80 recording said transport stream on an optical disk. medium.

16. The method of claim 10 including the further step of:

85 transmitting said transport stream over a microwave link.

17. The method of claim 10 including the further step of:

90 transmitting said transport stream from one computer to another via a packet communications link.

18. The method of claim 10 including the further step of:

95 editing said transport stream using a computer.

19. A video compression system comprising:

100 a source of luminance signal and first and second color difference signals descriptive of successive fields of video information;

an input processor for converting said luminance signal and said first and second color difference signals into frames of video information having a 4:2:0 sampling format; and

105 video compression apparatus for performing intraframe compression encoding on each consecutive frame of the video information having a 4:2:0 sampling format, said intraframe compression encoding being done using discrete cosine transformation of blocks of pixels in
110 each frame of video information and subsequent compression encoding of each consecutive transformed frame in accordance with the MPEG-2 standard for intraframe compression encoding of selected frames of video, said intraframe compression encoding including the
115 identification of each consecutive frame as being intraframe compression encoded, the results of the

- 55 -

intraframe encoding being supplied by said video compression apparatus as a stream of compressed video data.

120

20. The video compression system of claim 19 in combination with:

an MPEG-2 decoder for decoding said stream of compressed video data.

125

21. The video compression system of claim 195 in combination with:

an MPEG-2 decoder for decoding said stream of compressed video data; and

130

television display apparatus for displaying television images responsive to decoding results from said MPEG-2 decoder.

135

22. The combination of claim 21, wherein said source of luminance signal and color difference signals descriptive of successive fields of video information is a video camera, and wherein said television display apparatus is operable as a camera viewfinder.

23. The combination of claim 22 further comprising:

140

decoding results memory for temporarily storing said decoding results from said MPEG-2 decoder; and

a printer for printing a selected frame read to said printer from said decoding results memory.

- 56 -

145 24. The combination of claim 21 further comprising:

decoding results memory for temporarily
storing said decoding results from said MPEG-2 decoder;
and

150 a printer for printing a selected frame read to
said printer from said decoding results memory.

25 . The video compression system of claim 19 included
in a video recording system for recording said compressed
video information in variations of the magnetization of
155 a magnetic tape recording medium, said video recording
system further comprising:

electromagnetic tape recording apparatus having a
tape transport for said magnetic tape recording medium,
having heads mounted on a head drum for helically
160 scanning said magnetic tape recording medium as
transported thereby, and having a rotary transformer for
transformer coupling signals to and from said heads;

a modulator responsive to a modulating signal for
generating modulation results without substantial direct
165 component for transformer coupling via said rotary
transformer to said heads during times of recording said
compressed video information;

a transport stream assembler for assembling a
transport stream of data by
170 time-division-multiplexing said stream of compressed
video data with other data; and

an error-correction encoder for forward error
correction encoding said transport stream of data to
generate error-correction-coding results applied to said

175 modulator as said modulating signal.

26. The video recording system set forth in claim 25, wherein said modulator is a 24/25 modulator for generating I-NRZI modulation.

180

27. The video recording system set forth in claim 25, wherein said error-correction encoder performs Reed-Solomon forward error correction encoding on said transport stream to generate said error-correction-coding results.

185

28. The video recording system set forth in claim 25 included in a system for recording and reproducing video information, which system for recording and reproducing video information further comprises:

190

a demodulator for demodulating reproduced modulation results coupled thereto from said heads via said rotary transformer during times of playing back said compressed video information as previously recorded on said magnetic tape recording medium, said demodulator supplying during those times demodulation results that reproduce said modulating signal;

195

an error-correction decoder for error correction decoding said demodulation results to reproduce said transport stream of data;

200

a transport stream disassembler for disassembling said transport stream of data to reproduce said stream of compressed video data by time-division de-multiplexing said compressed video data from said other data;

- 58 -

205 an MPEG-2 decoder for decoding the reproduced stream of compressed video data; and

television display apparatus for displaying television images responsive to decoding results from said MPEG-2 decoder.

210

29. The video recording system set forth in claim 28, wherein said modulator is a 24/25 modulator for generating I-NRZI modulation.

215 30. The video recording system set forth in claim 29, wherein said error-correction encoder performs Reed-Solomon forward error correction encoding of said transport stream of data to generate said error-correction-coding results, and wherein said

220 error-correction decoder decodes the reproduced Reed-Solomon error-correction-coding results in said demodulation results to reproduce said transport stream of data.

225 31. The video recording system set forth in claim 25 further comprising:

230 a demodulator for demodulating reproduced modulation results coupled thereto from said heads via said rotary transformer during times of playing back said compressed video information as previously recorded on said magnetic tape medium, said demodulator supplying during those times demodulation results that reproduce said modulating signal;

an error-correction decoder for error correction

235 decoding said demodulation results to reproduce said
transport stream of data;

a transport stream disassembler for disassembling
said transport stream of data to reproduce said stream of
compressed video data by time-division de-multiplexing
240 said compressed video data from said other data;

an MPEG-2 decoder for decoding the reproduced
stream of compressed video data;

television display apparatus for displaying
television images responsive to decoding results from
245 said MPEG-2 decoder;

decoding results memory for temporarily storing
said decoding results from said MPEG-2 decoder; and

a printer for printing a selected frame read to
said printer from said decoding results memory.

250

32. The video recording system set forth in claim 31,
wherein said modulator is a 24/25 modulator for
generating I-NRZI modulation.

255 33. The video recording system set forth in claim 32,
wherein said error-correction encoder performs Reed-
Solomon forward error correction encoding of said
transport stream of data to generate said error-
correction-coding results, and wherein said

260 error-correction decoder decodes the reproduced Reed-
Solomon

error-correction-coding results in said demodulation
results to reproduce said transport stream of data.

265 34. The video compression system of claim 19, further including:

a microwave transmitter for transmitting said results of said intraframe compression.

270 35. The video compression system of claim 34 in combination with:

a microwave receiver for receiving said results of said intraframe compression transmitted by said microwave transmitter; and

275 a digital tape recorder for recording said results of said intraframe compression as received by said microwave receiver.

36. The video compression system of claim 19, in combination with:

280 a computer for editing the results of said intraframe compression; and

apparatus for storing the edited results of said intraframe compression within a storage medium.

285 37. Video reproduction apparatus for reproducing video information recorded on a recording medium after being encoded using intraframe compression coding corresponding to that used in MPEG-2 video compressors, said video reproduction apparatus comprising:

290 playback apparatus for reproducing a modulated electric signal responsive to variations recorded in the recording medium;

- 61 -

a demodulator for reproducing a modulating signal used to generate said modulated electric signal;

295 an error-correction decoder for error correction decoding said demodulation results to reproduce a transport stream of data;

a transport stream disassembler for disassembling said transport stream of data to reproduce a stream of
300 compressed video data by time-division de-multiplexing said compressed video data from other data; and

an MPEG-2 decoder for intraframe compression decoding the reproduced stream of compressed video data to recover a sequence of consecutive frames of video
305 information in decompressed form.

38. Video reproduction apparatus as set forth in claim 37, wherein said playback apparatus comprises electromagnetic tape playback apparatus for reproducing
310 a modulated electric signal responsive to variations in the magnetism of a magnetic tape recording medium.

39. Video reproduction apparatus as set forth in claim 37, wherein said playback apparatus comprises optical
315 disk playback apparatus for reproducing a modulated electric signal responsive to variations in the surface of an optical disk recording medium.

1/13

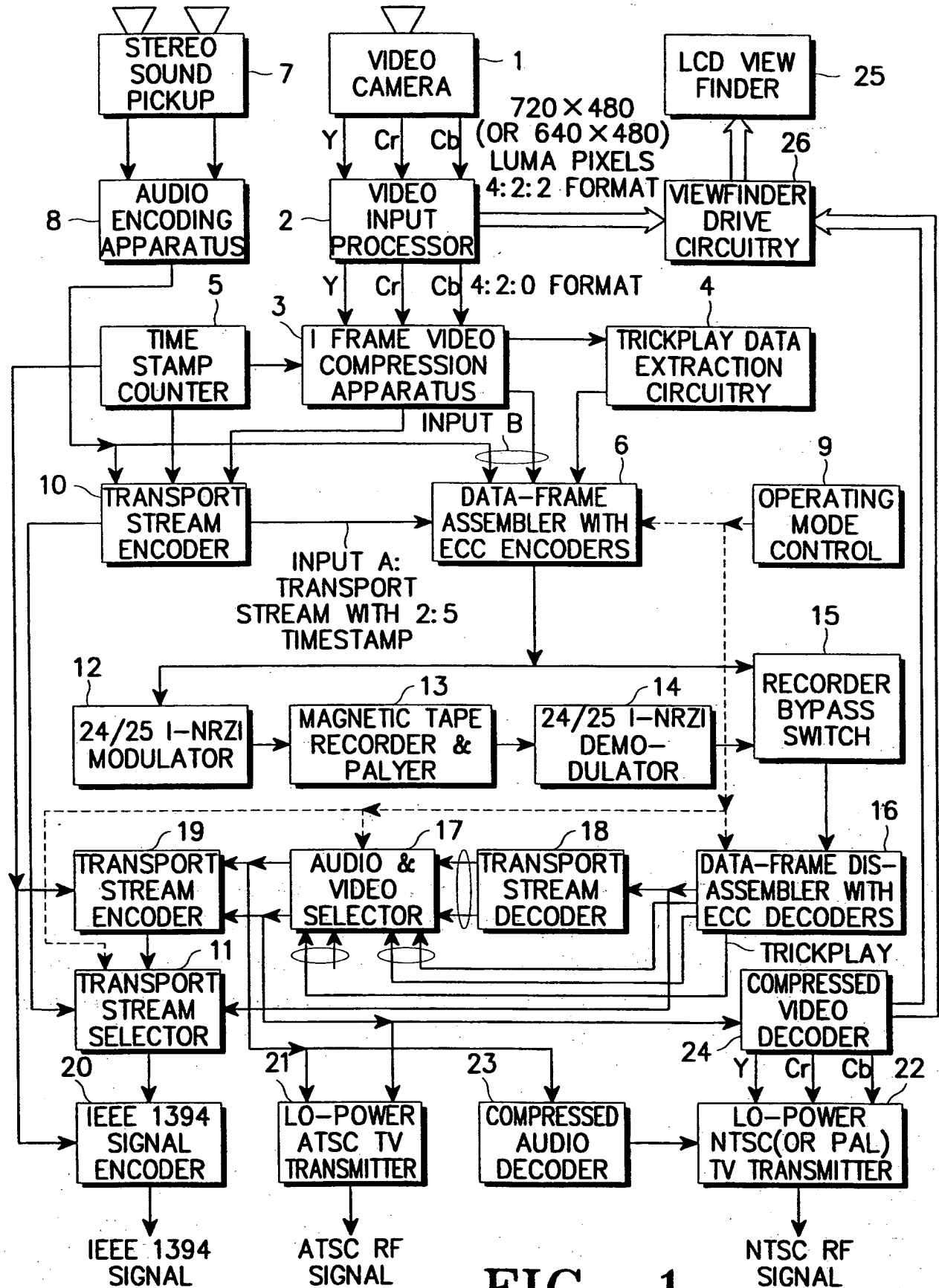


FIG. 1

2/13

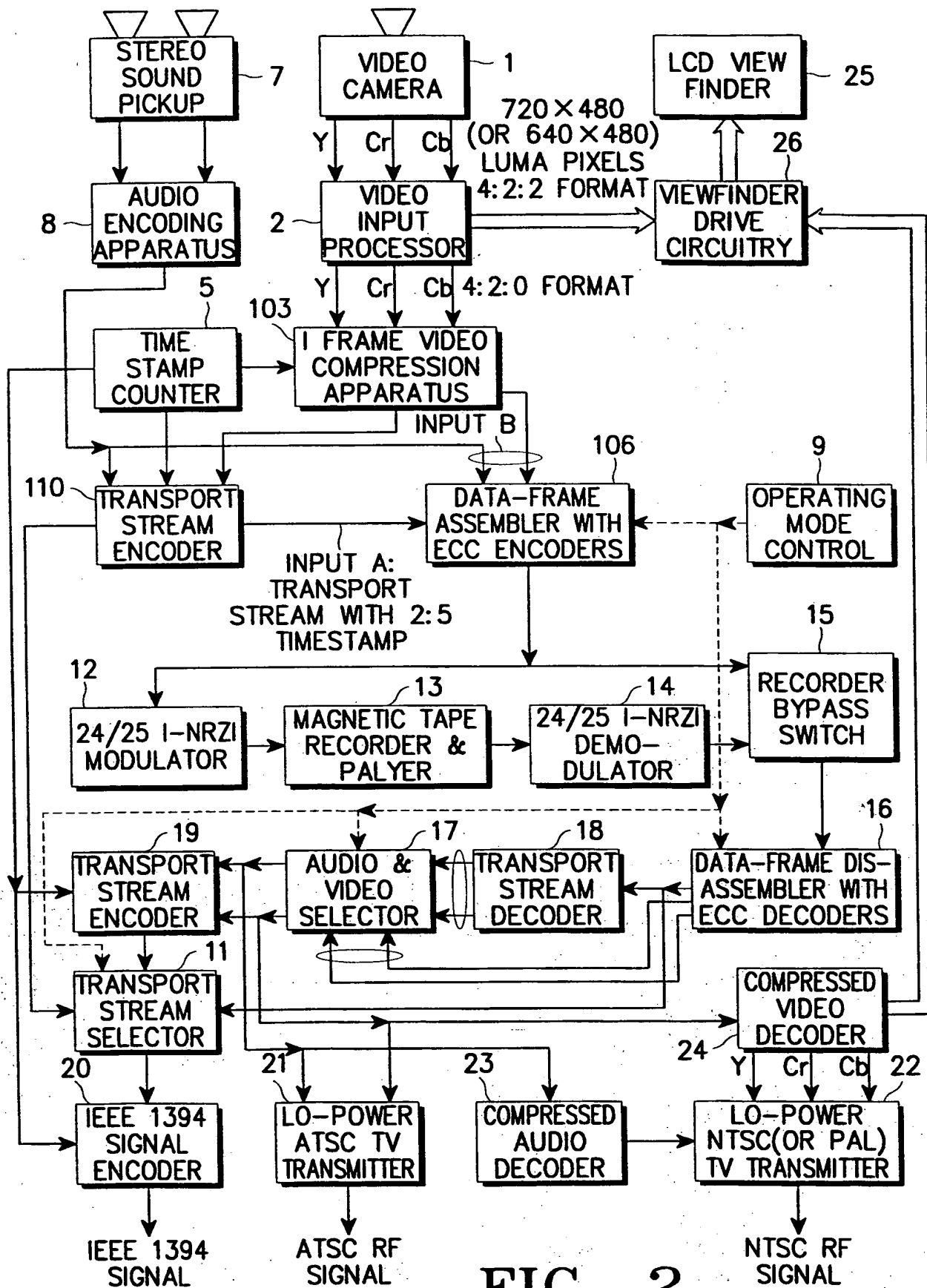


FIG. 2

3/13

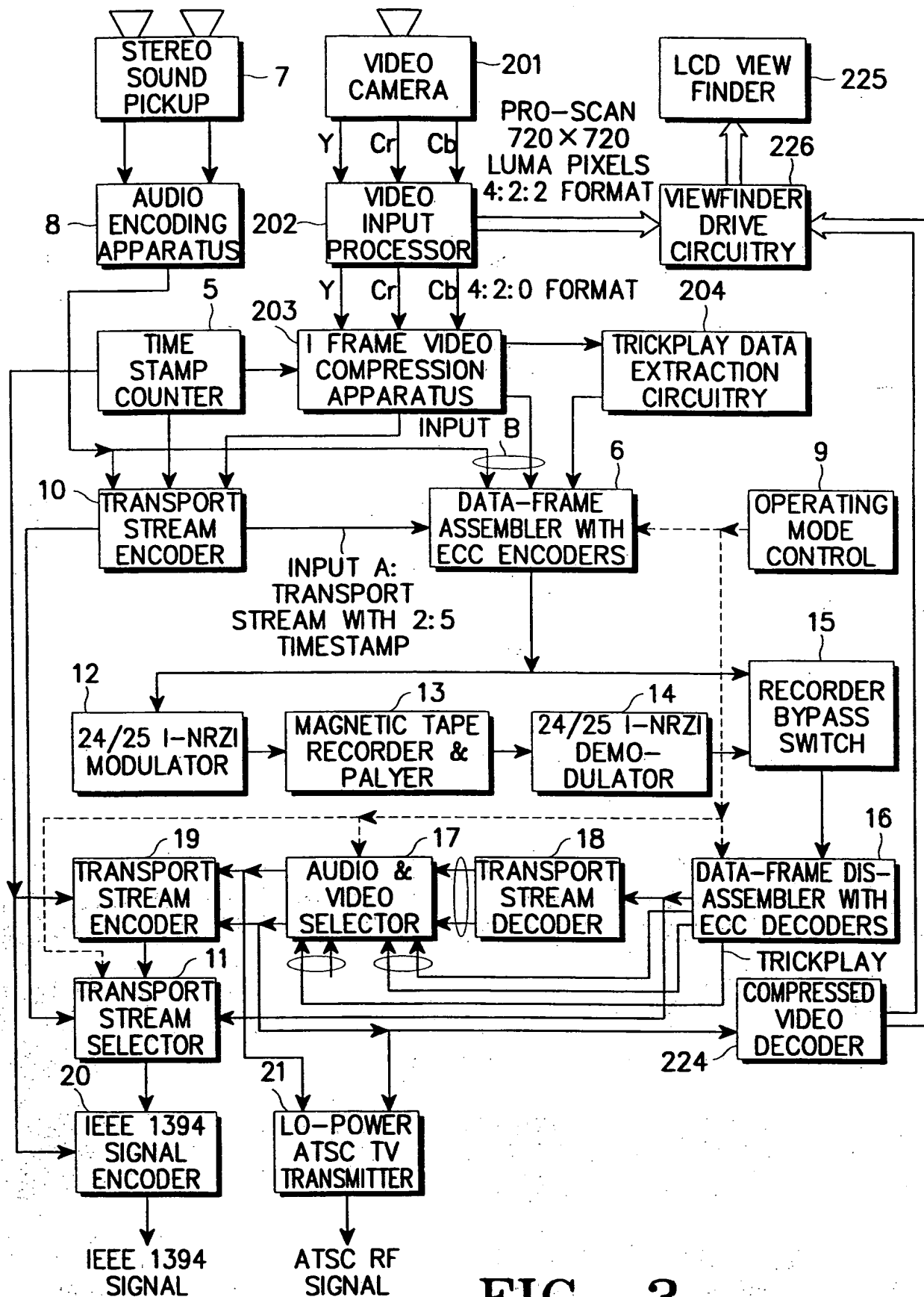


FIG. 3

4/13

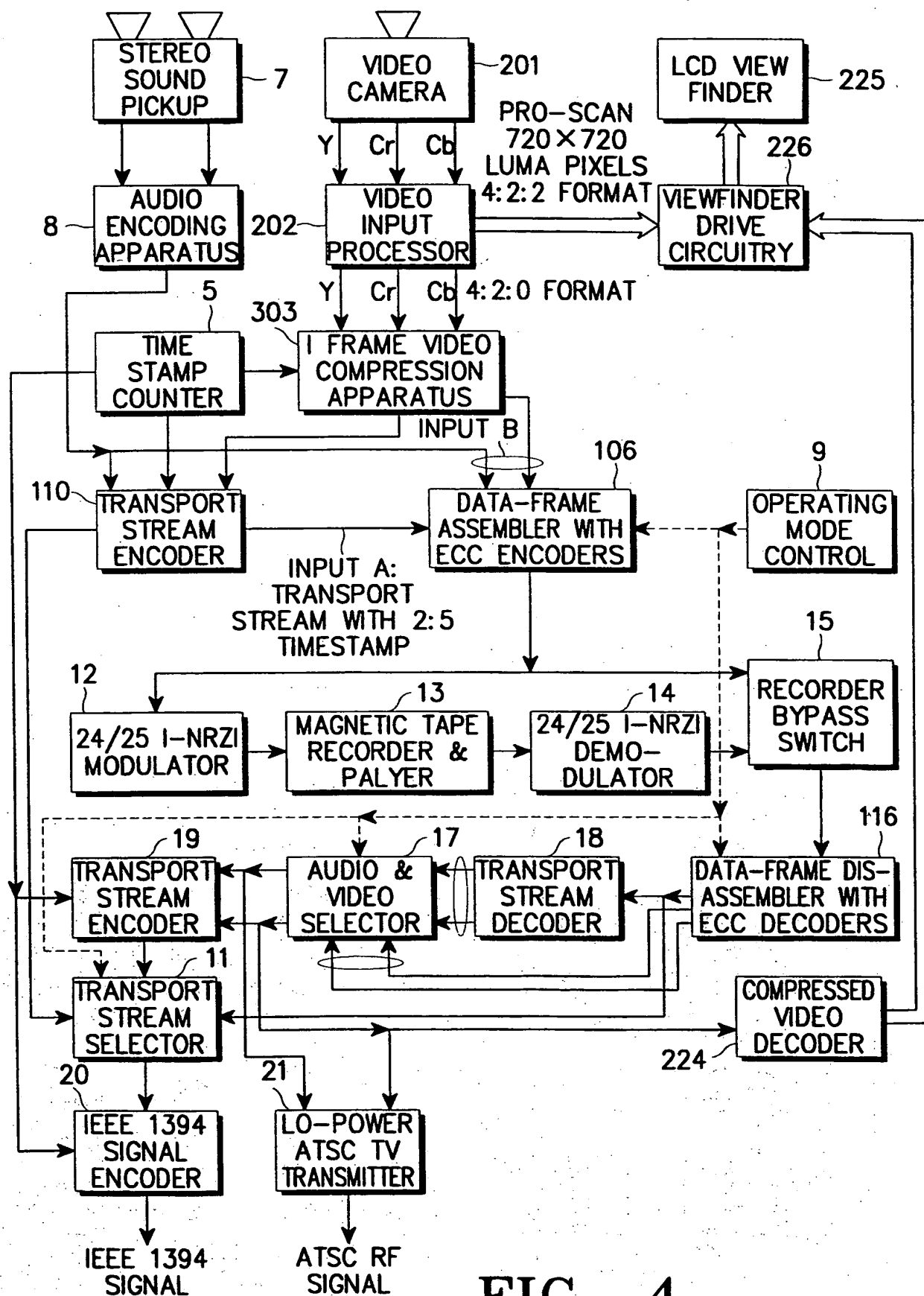


FIG. 4

5/13

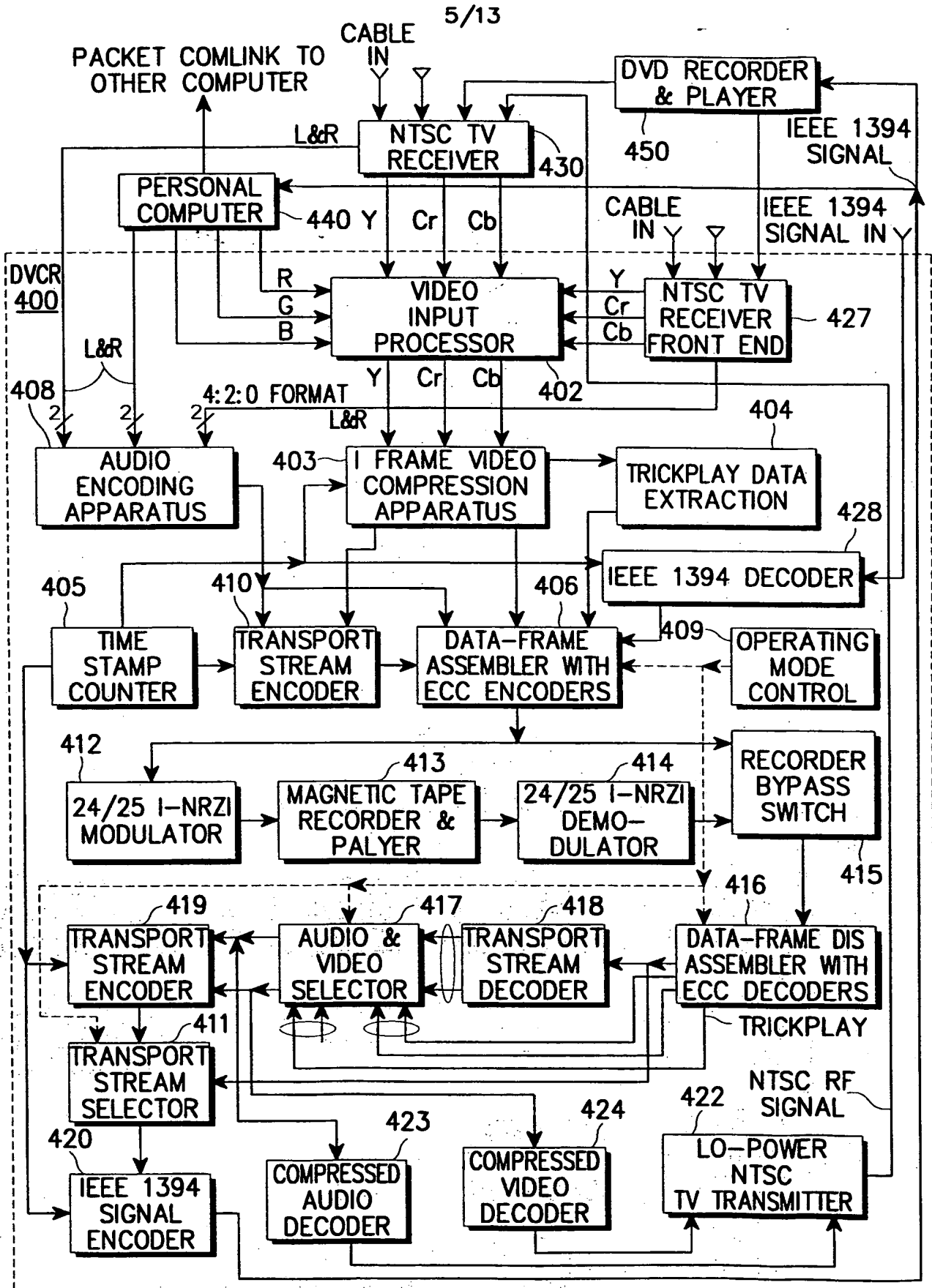


FIG. 5

6/13

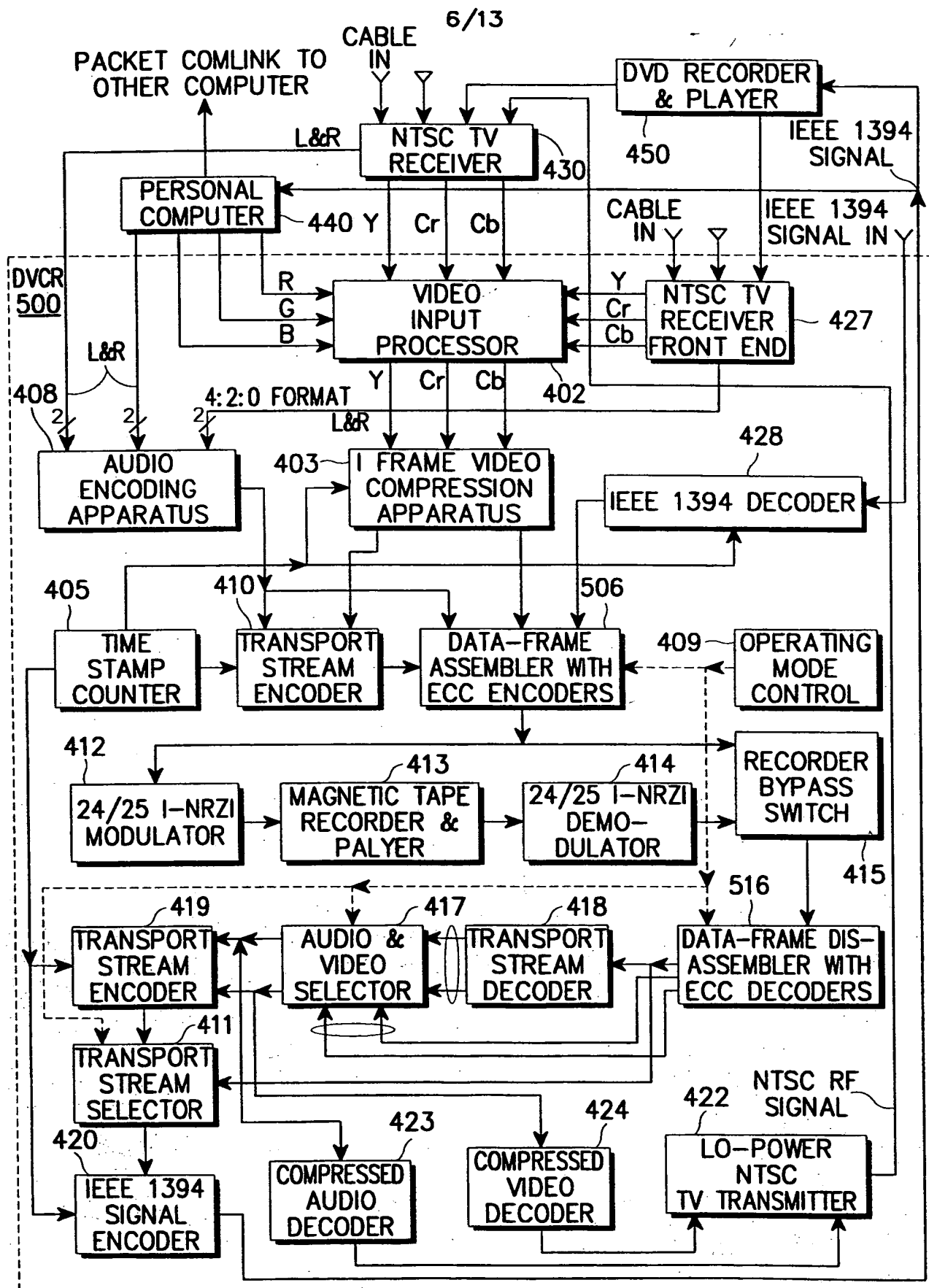


FIG. 6

7/13

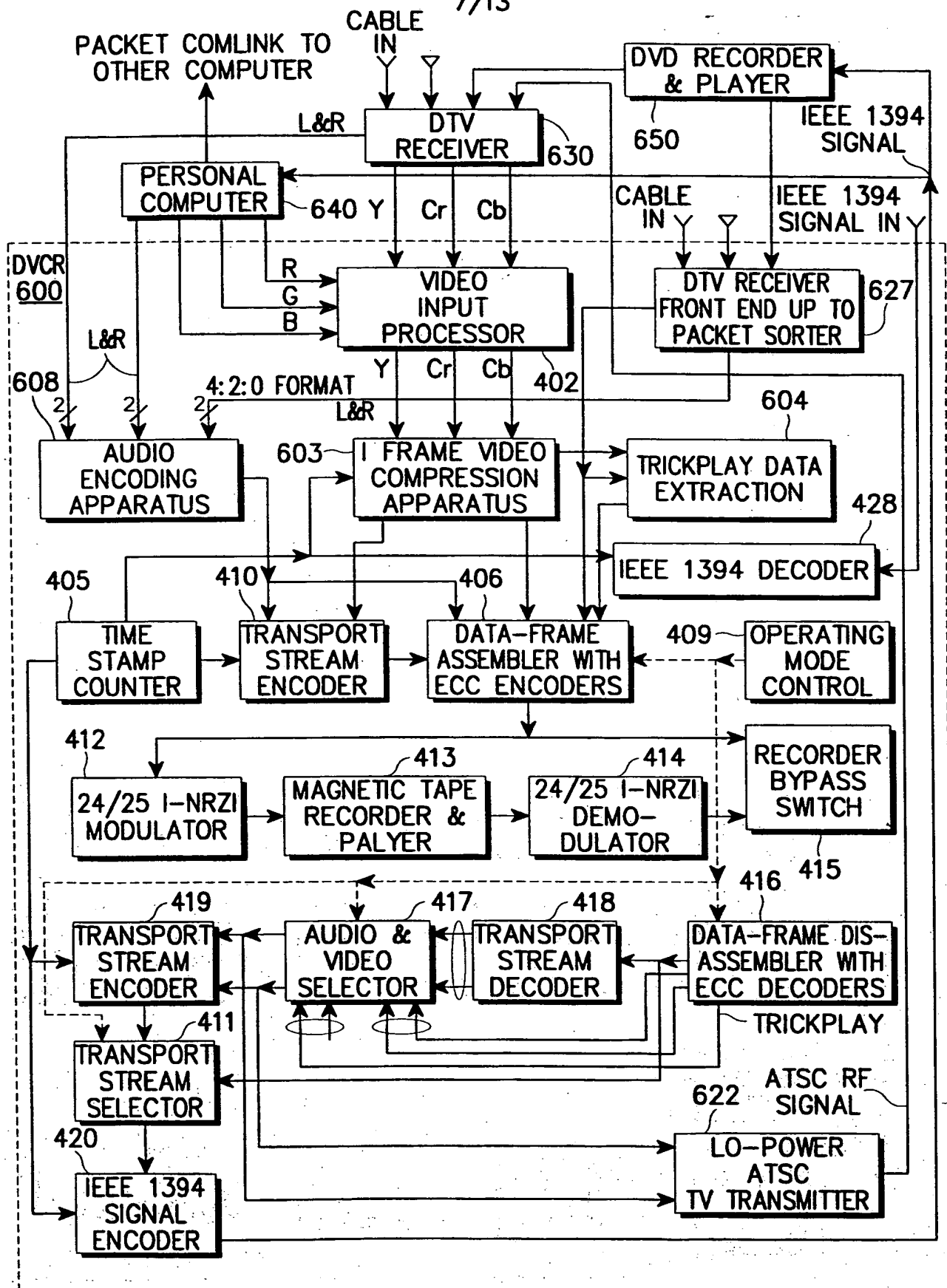


FIG. 7

8/13

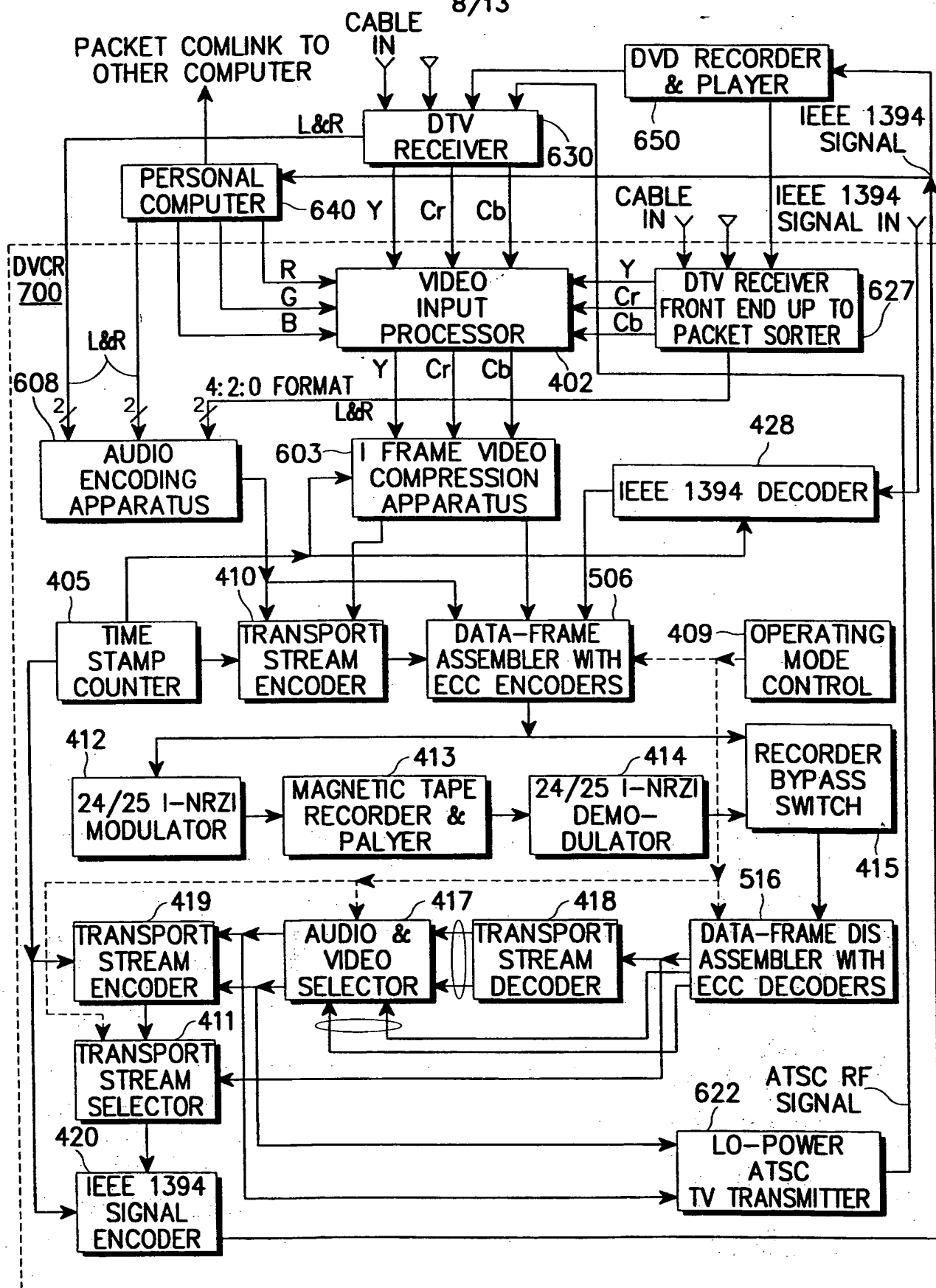
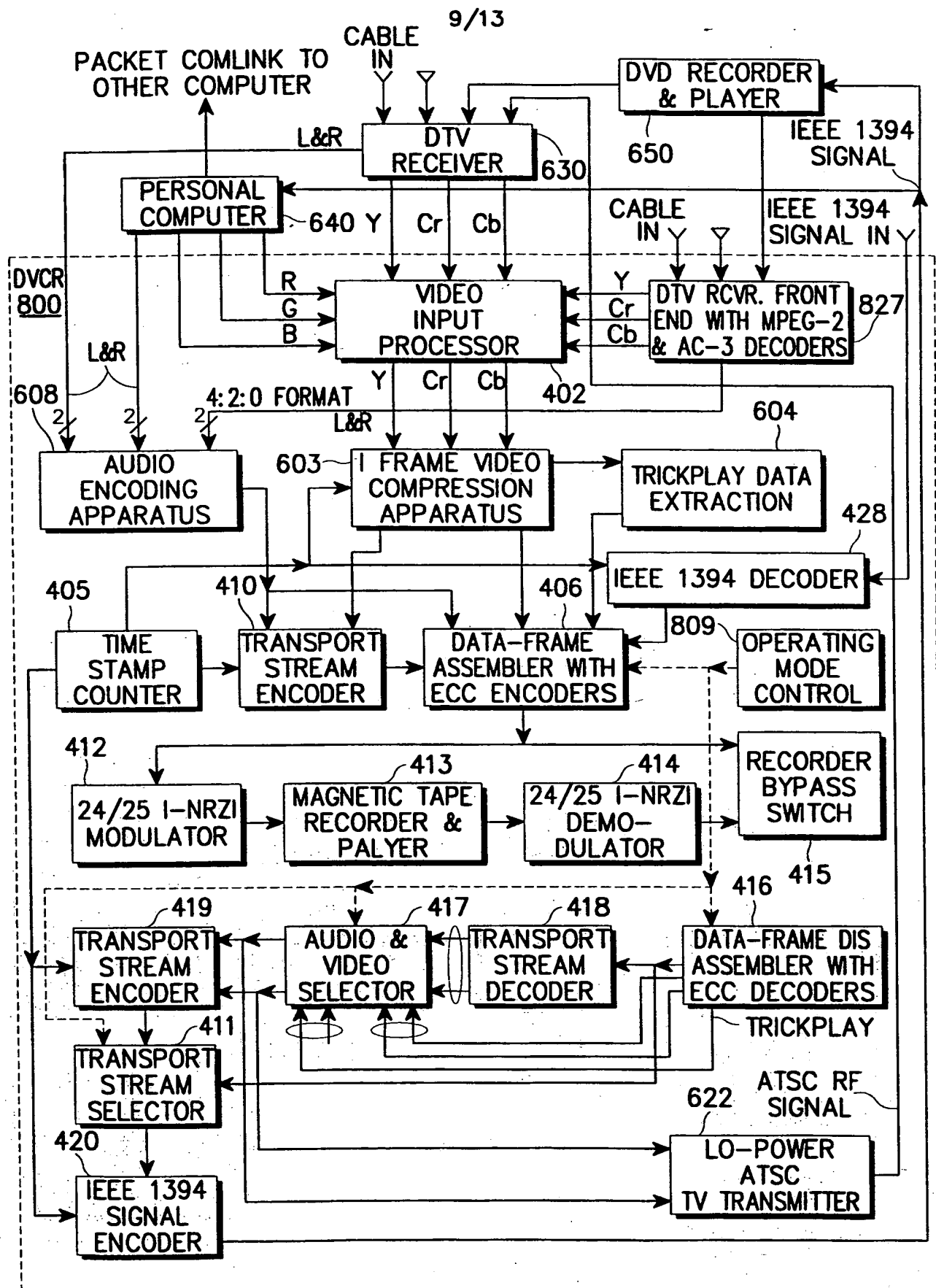


FIG. 8



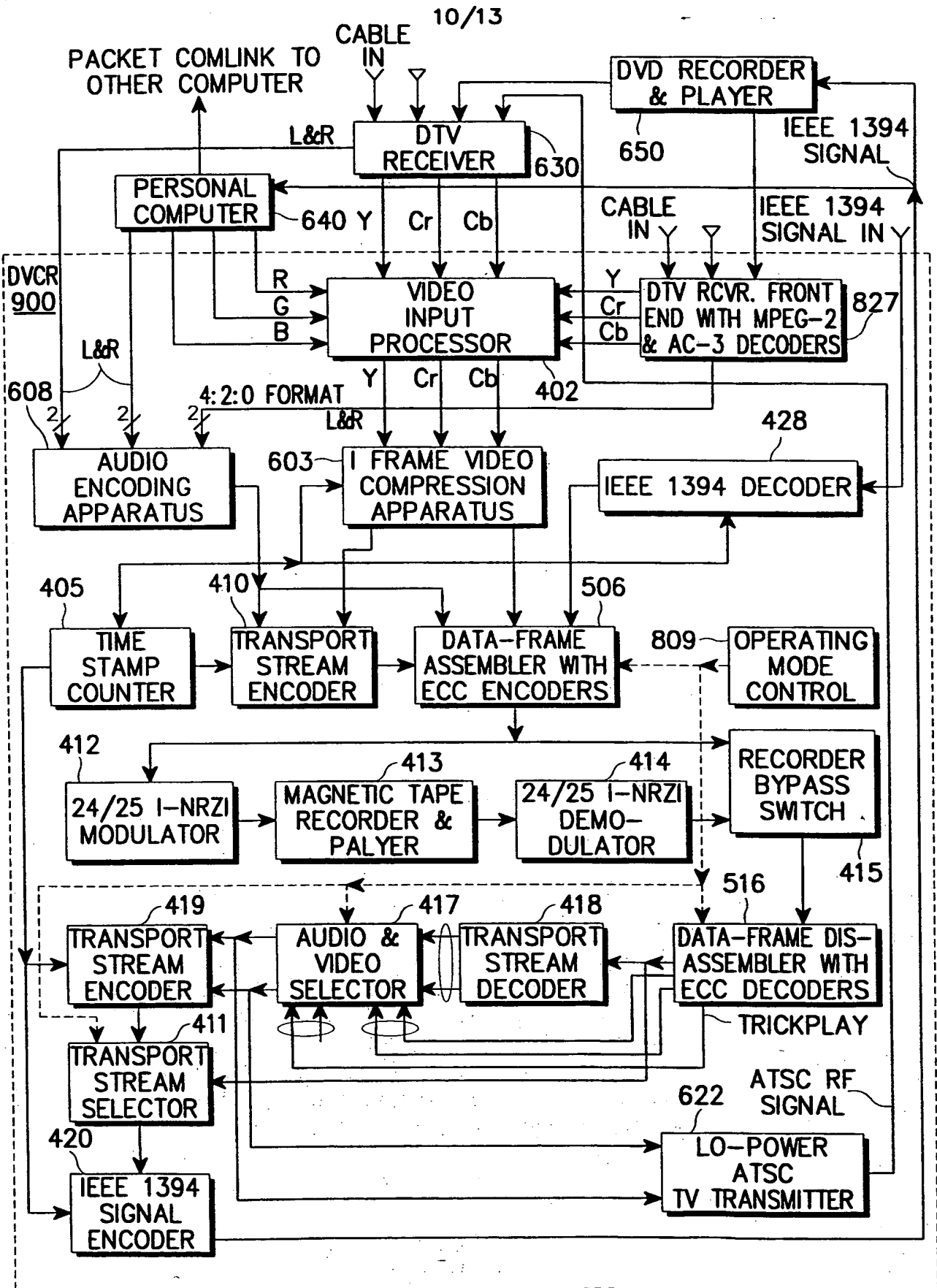


FIG. 10

11/13

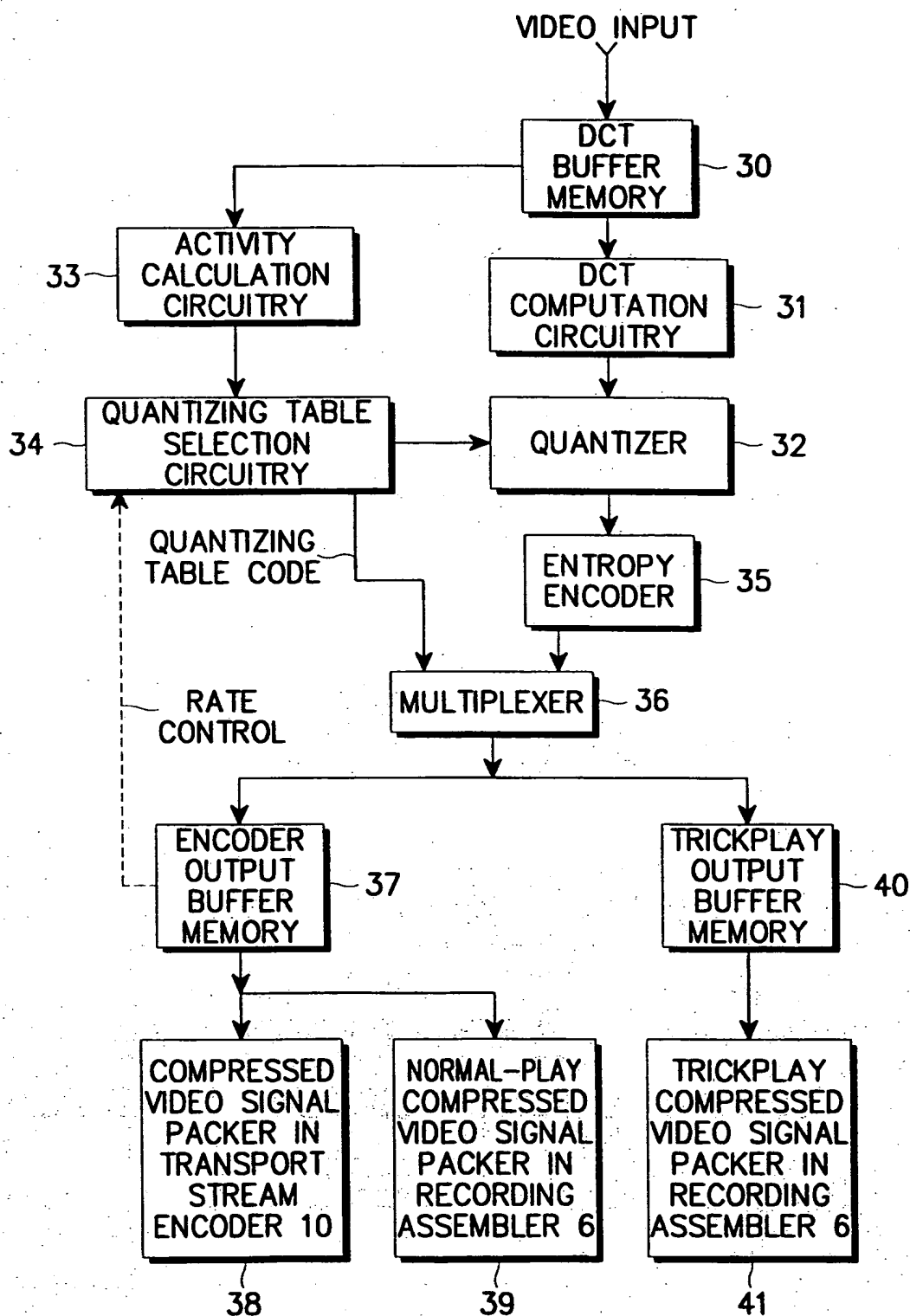


FIG. 11

12/13

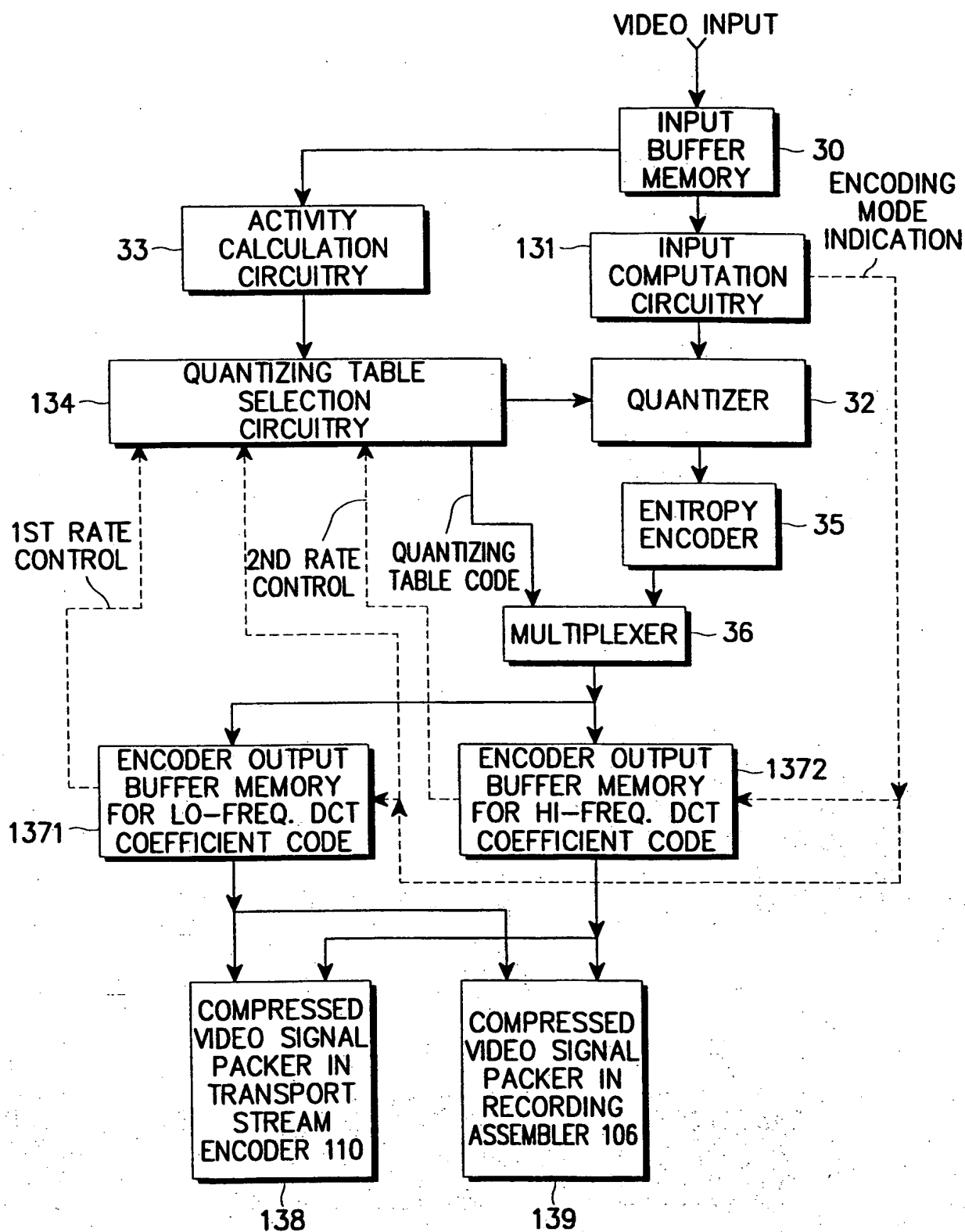


FIG. 12

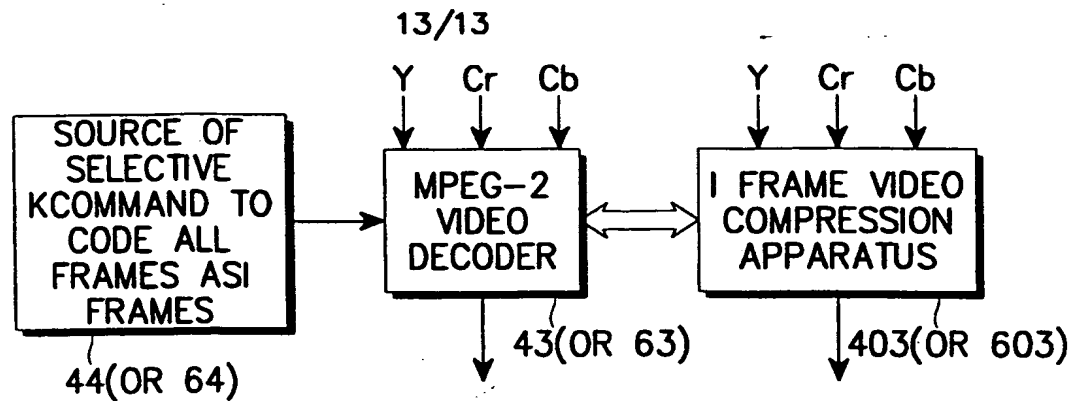


FIG. 13

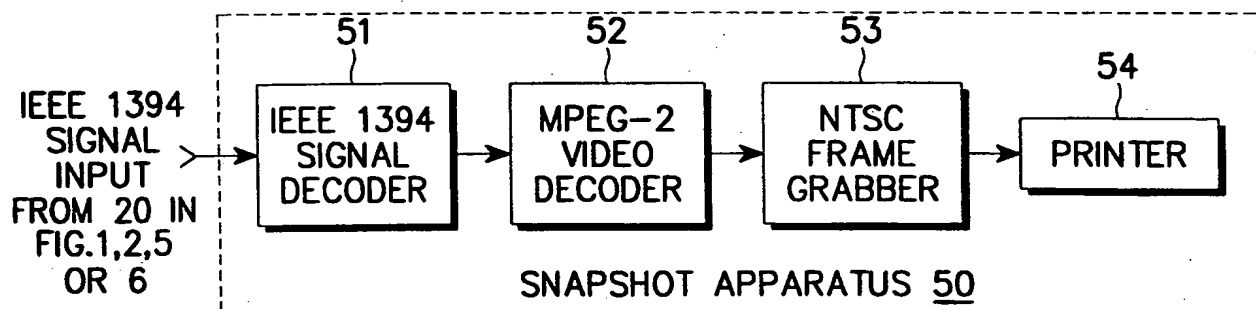


FIG. 14

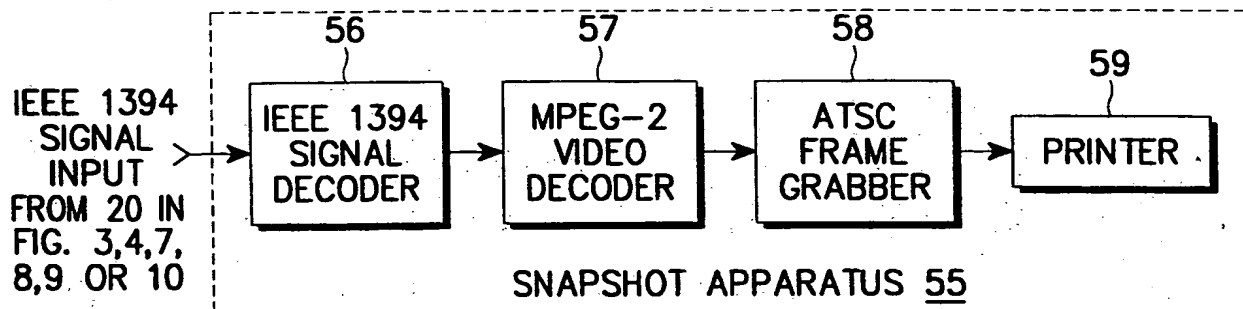


FIG. 15

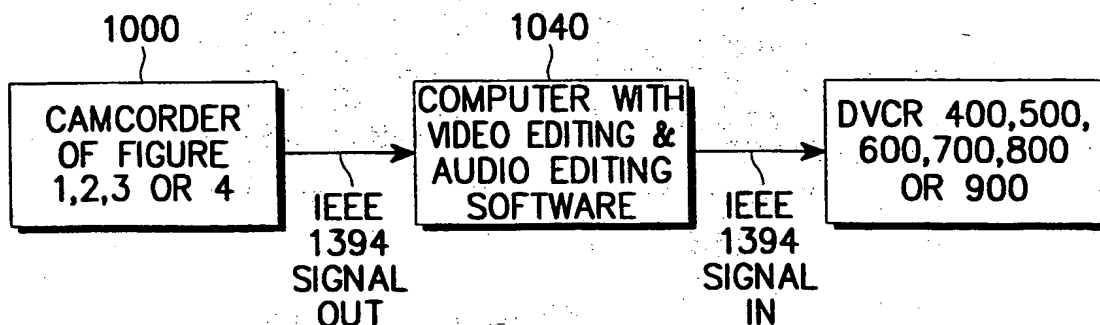


FIG. 16

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR 98/00249

A. CLASSIFICATION OF SUBJECT MATTER

IPC⁶: H 04 N 7/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁶: H 04 N 7/04, 7/26, 7/30, 9/80, 9/804, 9/81

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|----------------------------|
| A | EP 0 705 041 A2 (SONY CORP.) 03 April 1996 (03.04.96), fig.6; claims 1-9. | 1-3, 10-12, 19-21, 25, 37 |
| A | US 5 329 365 A (RCA THOMSON LIC. CORP.) 12 July 1994 (12.07.94), fig.3; claims 1-5. | 1, 2, 8, 10, 11, 17, 19-21 |
| | ---- | |

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

| | |
|---|--|
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| "E" earlier application or patent but published on or after the international filing date | "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "&" document member of the same patent family |
| "O" document referring to an oral disclosure, use, exhibition or other means | |
| "P" document published prior to the international filing date but later than the priority date claimed | |

Date of the actual completion of the international search

21 December 1998 (21.12.98)

Date of mailing of the international search report

12 January 1999 (12.01.99)

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